# PROCEEDINGS

OF THE

## Eighth Annual Convention

OF

# The Traveling Engineers' Association

## Cleveland, Ohio

September 11, 12, 13 and 14, 1900

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EDITED BY

W. O. THOMPSON, SECRETARY.

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"TO IMPROVE THE LOCOMOTIVE ENGINE SERVICE ON AMERICAN RAILROADS."

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| W. J. WALSH | Cleveland, Ohio. |
| J. R. BELTON | Covington, Ky. |

# PROCEEDINGS.

The Eighth Annual Convention of the TRAVELING ENGINEERS' ASSOCIATION, held at the Colonial Hotel, Cleveland, Ohio, Ohio, September 11–14, inclusive, 1900.

TUESDAY, Sept. 11, 1900.

President P. H. Stack called the meeting to order at 9:50 a. m.

The President: We will open the Convention with prayer.

Prayer was offered by Rev. Ward Beecher Pickard, pastor of the Epworth Memorial Methodist Episcopal Church, Cleveland.

The President: Ladies and Gentlemen—I take pleasure in introducing Mr. M. W. Beacon, Corporation Counsel, representing Mayor J. H. Farley. Mr. Beacon will address a few remarks to you.

## M. W. BEACON'S ADDRESS.

MR. PRESIDENT, GENTLEMEN OF THE TRAVELING ENGINEERS' ASSOCIATION, LADIES AND GENTLEMEN,—The Hon. J. H. Farley, Mayor of the city of Cleveland, asked me to appear here for him and speak a few words of welcome to you. He, as the head of the municipality, naturally should have come here, and I regret very much, as does he, that his absence during the entire month threw such a burden of work upon him that it is impossible for him to meet all of the engagements which he would naturally have to fill, and so I come to represent him, come rather suddenly with only a very short notice, which I regret for I have not had time to prepare an address which I should like to do. There is another reason why Mr. Farley should have come here outside of the fact that he is the official head of the municipality, for he is a born engineer. If you had lived in the city of Cleveland, you would know that Mr. Farley could build an engine if he undertook it; while he has never had the training of an engineer, yet he has been interested in your work, and there is no subject he would rather talk about than the water works, engines and

machinery. But while he should have come he could not, and I come and want to assure you gentlemen that I come gladly, and with very great pleasure, for I want to say to you in the greatest sinceritv that no convention of men has ever met in this town and no convention of men will ever meet in this town for whom I have a more profound respect than I have for this. I do not know any class of men who can represent more of the qualities which adorn human nature than the railroad engineers. I do not know any class of men whose occupation requires more high and admirable qualities than yours does, for I take it that no man can be a railroad engineer who is not temperate, honest, faithful and brave; those are not mere words, they are facts. I have been on the water a great many times and I have always admired the captain of the vessel standing upon the bridge always looking out for the hidden rocks to ward off the danger to his precious cargo; but is not that exactly what the engineer does, always watching out to avoid collisions, the broken rail, the defective bridge, the damage done by floods, the obstructions placed on his track by lawless people; always on the lookout, always watchful and brave, trying to guard against danger to property and the lives intrusted to his care? Gentlemen, these are not mere words; I admire you and your calling exactly as I admire the captain of the ships that sail the ocean, and I take it that your dangers are greater in the course of your lives than are the dangers to any other body of men, for in the course of forty years' service, which is about the time of your service I believe, you run more risks of injury and of loss of life than the men in the ordinary service of any company in the world.

Now, ladies and gentlemen, I welcome you to this town in the name of the Mayor and in the name of the people of Cleveland, and I think it particularly appropriate that you should come to this city and at this time; it is not only the metropolis of Ohio, it is not only next to Chicago the greatest city on the great lakes, but situated as it is at the southern point of the great lakes, handling both coal and iron ore, it has become the center for the manufacture of iron and steel, and as time goes on it is becoming a business center for the things which you use; the things with which you are familiar, in fact with all those things which are used in the construction of stationary engines, in ship building and the building of the machinery for ships and of all sorts of interests in this city, in this country and in fact all over the world. We are very well pleased that engineers should visit the city of engineering. Futhermore I do not believe there is in the world a place where the climate is more delightful than our climate is during the months of September, October and November and part of December. It is just as soft and as charming as any of the

famous Italian places, and I trust that Providence will be kind to you during your stay here, and give you the pleasure of the climate we usually enjoy here.

Now, ladies and gentlemen, I will not take your time any further; again saying that the Mayor welcomes you, that the city welcomes you and all of the people welcome you, are glad to see you, respect you and your work, are interested in you and your work, and trusting you will go away from this town with delightful recollections, with charming new friendships, with pleasant thought for us and the town in which we live, I thank you all for your attention and for having had the pleasure of saying in words the admiration I feel for so brave and interesting body of men. (Applause.)

President Stack: Mr. Beacon, on behalf of the members of the Traveling Engineers' Association I thank you for your words of welcome, and I will call on Mr. Walsh, a member of this Association, and a life long resident of this city, to make the reply.

## J. F. WALSH'S REPLY.

MR. PRESIDENT, LADIES AND GENTLEMEN: It is an unusual thing and is the first time in the history of our Association that we have met consecutively in the same state. I want to explain to you how it came about. Two years ago we held our convention at Buffalo; while there we concluded to hold the next convention in the state of Ohio, and so we pitched upon the little town of Cincinnati. Now Cincinnati, I will say, treated us hospitably, kindly, and the members of our Association, their ladies and friends were very much pleased with the treatment received in Cincinnati. The Business Men's League of the city of Cleveland, however, learning that we had made a mistake in picking out Cincinnati as the metropolis of the state, sent their representatives, Mr. Lee and Mr. Ball, down there to explain matters, to assure us that while they were sure Cincinnati would treat us kindly it could not, nor could any other city, do justice to the state; consequently they invited us to the city of Cleveland, and here we are, and as a resident of the city of Cleveland (I have lived here all my life) I thank you for the hearty welcome you have given us, and I doubly thank you for the welcome you have given our ladies, God bless them; it costs us a good deal to dress them, but what can we do. (Applause.)

President Stack: I see we have Mr. Delos Everett, of the Grand Lodge of the Brotherhood of Locomotive Engineers, with us. We would like to hear from him.

## DELOS EVERETT'S ADDRESS.

Mr. President, Ladies and Gentlemen: I was to make an address on one occasion and I wrote to a friend of mine asking what I should say on such an auspicious occasion. "Well," he said, "Brother Everett, you will have to be governed by your environments," and this morning I find my environments to be beautiful women and splendid men in one of the best appointed hotels, I guess, there is in the United States.

I am here this morning on behalf of the Brotherhood of Locomotive Engineers to extend to you a hearty welcome to the city of Cleveland, which has been so well proffered you by the representative of the Mayor, only this gentleman was so modest about the beauties of Cleveland that he did not tell you half of them. It is because, I suppose, he wanted to take you by surprise. He forgot to tell you that the state of Ohio is historical, every foot of it. We used to say that Virginia was the Mother of Presidents, but I guess that now Ohio is the Mother of Presidents.

I am sure if I could go over this country today and consult my engineers I am satisfied every one would say to me, please give the Traveling Engineers our hearty welcome, please give to them our sympathy and our best wishes for the success of their meeting in Cleveland. I am sorry that Brother Arthur, our Grand Chief Engineer, could not be here. He told me to present his regards to this meeting, and to extend to you his hearty greetings on this occasion, that you have his sympathy in your work and that he trusts your stay will be very pleasant in the city of Cleveland. Personally, I hope you will go away more than pleased with our city, and as the gentlemen who preceded me said, that you will form charming friendships here that will never be broken.

With a hearty God bless you I hope your stay in Cleveland will be more than pleasant.

President: We would like to hear from Mr. Conger in reply to Mr. Everett.

## C. B. CONGER'S REPLY.

Mr. President, Ladies and Gentlemen: We appreciate the fact that the people welcome us here, and we came to Cleveland because we knew we would be welcome, that it would be a beautiful city, which I do not think we need go into detail about now. But we certainly, as an Association, are obliged to the orators for their kind words and to Brother Everett for pledging the support of the Brotherhood of Locomotive Engineers to us. Certainly the Traveling Engineers need the support of the

Association which is so powerful, and to which so many of us belong, fully ninety-five per cent. of the Traveling Engineers being members of the B. of L. E. But this is an educational enterprise and we are here for business, and I think instead of taking up the time in thanking the officials of the city over again, we had better proceed right straight to business and show them that we know how to do business, and if they will stay with us a few hours we will show them that we know how to do it.

President: LADIES AND GENTLEMEN: Our order of business calls for an address of the President.

## PRESIDENT'S ADDRESS.

LADIES AND GENTLEMEN: I take pleasure in welcoming you today to our Eighth Annual Convention, and in being able to congratulate the members of this Association on the healthy increase in membership. During the past yeaı we have lost only one member by death, Mr. George A. Hill, of the Galena Oil Company, who died July 17th, 1900.

The financial condition of the Association is all that could be desired, and I refer you to the Secretary's report on the same.

The Association is growing stronger each year among railway officials and employes, owing to the many valuable papers which have been prepared by the different committees and the very practical manner in which they have been discussed. The reading and discussion of these papers have been of great benefit to the railways by which we have been employed, and each and every one of you by imparting some of the information obtained at these meetings to the enginemen with whom you come in contact in your work, and with a little encouragement, will bring about the results that are expected from the line of work in which you are engaged, and serve to establish improvement of "locomotive engine service on American railroads." Another valuable part of the Annual Convention is the exchange of individual views and experiences.

The Association was requested this year to have a representative at the Master Mechanics' Convention, and was ably represented by Mr. McBain, who was chosen by their Executive Committee.

The very valuable committee reports which will be presented to this Convention are indicative of the painstaking care and thought devoted to their preparation, and I earnestly hope that the members present at each session during the Convention will enter into the discussions and express their views fairly and frankly on the different subjects.

We must not be satisfied with what we have accomplished in the past, but should aim to increase the usefulness of this Association. This can only be done by every member doing his duty towards aiding the different committees each year to prepare their papers, by attending annual conventions and by taking part in the discussions.

I would suggest that Section 6 of the By-Laws be lived up to at each day's meeting. If we cannot give one hour to the noon hour topical discussion, let us give at least one-half hour, as this discussion serves to bring forth valuable information, and I hope an interest in the topical discussion of our program will be manifested at this Convention.

Larger and more powerful engines, both simple and compound, are being adopted by many railways, and are taking the place of small engines. In some sections of the country it is a hard matter to keep firemen on those large engines, owing to the intense heat radiated from the large boiler heads, along with the extremely hot weather. Some effort should be made by the members of this Association to recommend to their Master Mechanics that these large engines be made as comfortable and convenient as possible for enginemen. A little expense along this line will be returned by a saving in fuel and better service.

The road on which I am employed has a number of 100-ton engines that carry 210 pounds of steam. Our company has covered the boiler heads, including the butt sheet with a non-conducting material, put injectors on the outside of cab, and put coal on tender to firing size. We find this pays for the reason that when enginemen are comfortable, and the appliances for doing their work are convenient, the saving of fuel and supplies will be the natural result. We have no trouble in keeping firemen on these engines in the hottest weather.

It is now an established fact that compound engines are beyond the experimental stage, and are taking the place of simple engines, both in passenger and freight service, and I would advise that this Association have the operation of compound engines one of the subjects for the next annual convention, as enginemen throughout the country are looking for good practical information on the different classes of compounds, and I know of no better way of obtaining the necessary information than to bring the subject before the Association.

Economy in fuel and supplies should always be uppermost in the minds of our members. There are a great many ways in which fuel can be easily wasted. One of the reports to be discussed at this convention will bring out many valuable points on the economical use of fuel.

The report on Indicators should be thoroughly discussed, as

this little instrument shows defect or irregularity in the distribution of steam which cannot be detected in any other way, and an uneven distribution of steam will greatly lessen the efficiency of the engine, with a consequent waste of fuel.

At least two air brake subjects should be taken up each year by this Association. Our air brake report this year, although considered before by this and our sister Association under various headings, is of the utmost importance, and a thorough discussion of this subject will be of great value to us.

The matter of hot driving and engine truck boxes is an important one, and one that should be thoroughly discussed.

The subject of Tank Valves, Goose Necks, Hose Strainer and Suction Pipes is more important than appears on the face of it. It is a fact that a great deal of trouble is experienced at times owing to the conical style of strainer used and in Injectors being placed too high above the water line. This subject should meet with a general discussion, which will no doubt bring out information that will enlighten us on some trouble we encounter in the operation of Injectors.

The question of electricity will be with us soon, as it is supplanting all steam engines on elevated and suburban lines. But I do not think electricity will supersede steam as a motor power on other than short suburban service for a long time to come, but it does seem to be an assured fact that it has come to stay in elevated and suburban service. The electric headlight is now in very extensive use on locomotives. The engineers should know something of the operation of a dynamo and of defects which may disable it while on the trip, that he can remedy so as to have the light burning again, and of the manner in which an arc light should be taken care of.

In conclusion I desire to express my appreciation of the valuable assistance and support given me by our Secretary and members in my performance of the duties of this office. I thank you all for the courteous treatment received at your hands, and I hope that the convention may be of interest and profit to all.

Ladies and Gentlemen: I thank you for your very kind attention, and I now declare the Eighth Annual Convention open and ready for any business that may come before us.

President: The next order of business is the report of the Secretary.

# REPORT OF SECRETARY.

*To the Officers and Members of the Traveling Engineers' Association:*

GENTLEMEN: At the close of the year 1898–1899, the membership of the Association was two hundred and fifty-seven. During the year 1899–1900, closing August 31, 1900, the total gain in membership was eighty-eight. We lost during the year four members by withdrawal; one was dropped on account of being unable to locate him, and had one death, or a net increase in membership of eighty-two, or thirty-one and nine-tenths per cent. Total membership Sept. 1, 1900, three hundred and thirty-nine.

The Seventh Annual report, or proceedings of the Cincinnati meeting, was issued in December last. Eight hundred and fifty paper bound and four hundred leather bound copies were printed. Each member was supplied with one leather and one paper bound copy.

You will note by the financial statement following, that the Association was never in as good condition as at the present time, both in point of membership and finances.

Statement of moneys received and disbursed, by your Secretary, during the year 1899–1900.

RECEIPTS.

| | | |
|---|---|---|
| Cash on hand Sept. 1, 1899 | $ 18.79 | |
| From membership dues | 835.00 | |
| " " fees | 440.00 | |
| " advertising in Seventh Annual Report | 296.25 | |
| " sales of Annual Reports | 51.79 | $1641.83 |

DISBURSEMENTS.

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| Miscellaneous expense of Seventh Annual Meeting, order Executive Committee | $ 16.65 | |
| Reporting and transcript of proceedings, Seventh Annual Convention | 200.00 | |
| Printing and regular distribution of Seventh Annual Report | 377.54 | |
| Secretary, salary | 300.00 | |
| Remittance to Treasurer | 50.00 | |
| Books, stationery | 48.25 | |
| Printing of Circulars and Committee Reports | 57.10 | |
| Office expenses, postage, etc., D. R. McBain, as President | 6.78 | |
| Expenses of D. R. McBain representing The Traveling Engineers' Association at Master Mechanics' Convention at Saratoga | 23.82 | |
| Printing lists of members, by-laws, etc | 12.00 | |
| Office expenses, postage, stenographer, express, telegrams, etc | 195.32 | $1287.46 |
| Cash on hand | | 354.37 |
| | | $1641.83 |

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|---|---|---|---|
| There was due from members Sept. 1, 1900, dues | $847.00 | | |
| From sales of reports | 27.78 | | |
| From the United Investment Co., (List) | 2.42 | | |
| From advertising in Seventh Annual Report | 25.00 | | |
| Total prospective assets | $902.20 | | |

MEMBERSHIP 1899–1900.

| | | | |
|---|---|---|---|
| Total September 1st, 1899 | | | 257 |
| Received during year | | 88 | |
| Withdrew | 4 | | |
| Unable to find | 1 | | |
| Deceased | 1 | 6 | |
| Net Gain | | 82 | 82 |
| Total Membership Sept. 1, 1900 | | | 339 |

Net Increase, 31.9%

Respectfully submitted,
W. O. THOMPSON, Secretary.

The President: We will now hear the Treasurer's report.

Mr. Crane, Treasurer, read the following report:

## REPORT OF THE TREASURER.

*To the President and Members of The Traveling Engineers' Association:*

GENTLEMEN: Your Treasurer submits his report as follows:

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| Cash on hand last report, Sept. 1, 1899 | $200.00 |
| Cash received from W. O. Thompson, Sec., Aug. 18, 1900 | 50.00 |
| Total amount of cash on hand Sept. 11 | $250.00 |

DISBURSEMENTS.

None.

Respectfully submitted,
CHARLES A. CRANE, Treasurer.

The President: Ladies and Gentlemen, we will now have an intermission of five minutes to allow the ladies to retire.

After an intermission of five minutes the President called the meeting to order.

The President: Gentlemen, the next order of business will be the election of the Auditing Committee; the names of three members are now in order; no member of this committee can be an officer of the Association.

C. H. Hogan: Is the committee appointed by the President?

The President: No, they are elected by ballot.

C. B. Conger: I nominate Messrs. T. A. Hedendahl, Chas. F. Keith and G. W. Wilden.

S. D. Hutchins (W. A. B. Co.): I move that the nominations be closed.

Seconded by T. J. Bullock (Chesapeake & Ohio R. R.)

S. D. Hutchins: I move that the Secretary cast the ballot for Messrs. Hedendahl, Keith and Wilden.

Secretary Thompson: Mr. President, the Secretary casts the ballot for Messrs. Hedendahl, Keith and Wilden.

The President: The next order of business is unfinished business.

Secretary Thompson: There is nothing under the head of unfinished business, Mr. President.

The President: If there is no unfinished business, the next in order is new business.

Secretary Thompson: There is nothing under the head of new business, Mr. President.

The President: If there is nothing under this head, we will listen to the report of the committees. The members who have not this report will find them on the desk.

Secretary Thompson: There is a matter under the head of new business, Mr. President, which I failed to call your attention to. At the last meeting of the Air Brake Convention there was a committee appointed to confer with a committee to be appointed by the Traveling Engineers' Association at this meeting relative to holding the two meetings at the same place, one following the other, or something of that nature; their committee is here and I would suggest that their wishes be carried out, and that a committee be appointed to confer with the gentlemen. I make that as a motion.

The President: Motion has been made by Mr. Thompson, seconded by Mr. F. P. Smith, that a committee be appointed to confer with the Air Brake Men's Committee on whether the Traveling Engineers and the Air Brake Men can come to some agreement that the two Associations meet at the same time and place. Carried,

The President: We will appoint this committee later.

F. M. Nellis (Westinghouse A. B. Co.): Mr. President, I would like to make a suggestion as to the hours of meeting. Heretofore we have had two sessions a day, and the experience of the Air Brake Men's Association has been that we could get through with about four hours a day, and it gives a better attendance of the members and also gives a recess to the Convention, and I make a motion, unless it is in contradiction to the Constitution and By-Laws, that the meetings of this Convention be from nine until one, and that from twelve to one be reserved for topical discussions.

The President: Mr. Nellis, our Constitution and By-Laws provide that the hours of meeting shall be from nine until two, but I think it should be one o'clock, as two o'clock makes it too late for dinner.

Mr. Nellis: I do not see why it could not be changed. I think we would gain a better attendance by having shorter hours.

The President: Motion has been made by Mr. Nellis, seconded by Mr. F. P. Smith, that our hours be from nine until one o'clock each day. Carried.

The President: The hours of meeting will be from nine until one, and we will then adjourn until the following day. Is there anything further under the head of new business?

C. H. Hogan: It should be understood that the members will be here at nine o'clock sharp in the morning.

The President: We will open up at nine o'clock sharp each morning.

The next order of business is the reports of the committees. The first report is "How to Pack Boxes and what is the Best Kind of Waste to use to Insure the most Perfect Lubrication of the Bearings on our Engines." Mr. Meadows is the Chairman of this Committee, and will read it to you.

Mr. D. Meadows (M. C. R. R.) read the report as follows:

## How to Pack Boxes and What is the Best Kind of Waste to Use to Insure the Most Perfect Lubrication of the Bearings on Our Engines.

*To the President and Members of the Traveling Engineers' Association:*

GENTLEMEN: Your committee on the fourth subject for discussion at this meeting, viz "How to Pack Boxes and What is the Best Kind of Waste to use to Insure the Most Perfect Lubrication of the Bearings on Our Engines," beg leave to submit the following report. Your committee sent out a circular to all members asking for answers to all questions contained therein, and the report is largely compiled from the replies.

QUESTION 1. What kind of waste do you use in packing boxes on engines? The answers received to this question would indicate that woolen waste was used a great deal more than any other for packing or sponging, owing to its elasticity. One road uses cotton waste entirely but does not say why. Another uses old rope in cellars.

QUES. 2. Do you use the same kind of waste for all boxes on the engine? If you use different kinds of waste, say why. About all use the same kind.

QUES. 3. Do you use the same kind of waste for top of driving boxes that you do for the cellars, and do you use the same kind in the winter that you do in summer? If any difference, why? Most of the answers would indicate that the same kind of waste was used all the time, although quite a number favor cotton for top of driving and engine truck boxes, owing to the closeness of its fibre. It keeps the dirt out of the oil-holes and allows the oil to feed down more gradually than with woolen waste. A few use wool waste on top of boxes in winter and cotton in summer. The wool is used in winter as it allows the oil to pass through it more freely than the cotton.

QUES. 4. How do you prepare the packing? Do you soak the waste in oil? If so, say how long it should soak before being used, or do you oil the waste just previous to being used? All soak the waste from 12 to 48 hours and then allow the surplus oil to drain from it before being used, for if applied when soggy with oil it has very little elasticity, and in a short time settles away from the journal; or to make it plainer, if the packing is used when soggy with oil, it occupies so much space in the cellar or box that as soon as the surplus oil flows from it there is not sufficient packing left to keep it in contact with the journal.

QUES. 5. How do you place the packing in the boxes? Do you twist it up and put it in layers, simply put it in layers, tie it up in bunches or put it in just as you take it out of the bucket? Some use it as taken from the bucket, some make the packing into rolls and wind it with woolen string or wicking to prevent its winding or drawing out of place. Some simply twist it loosely in layers. There seems to be quite a diversity of opinion as to how these layers should be placed in cellars; some placing them in crossways, others lengthwise of the journal.

QUES. 6. Do you follow the same method for packing engine truck and driving box cellars, also tender truck boxes? If different methods are used, please explain and why so used. Nearly all use the same method for driving box and engine truck cellars, but in packing tender boxes the majority twist a roll of packing and put it up against journal at the back of box. This acts as a dust guard, also prevents the oil from running out at the back. Fill in the rest with packing as it comes from the bucket. Some put a roll at collar in front of box.

QUES. 7. Do you use the same oil for packing as you do on the other parts of the engine? If different, please say what difference and why. Nearly all use the same oil for all boxes. Four say use car oil for tender boxes, one says use car oil to get better results, and another uses car oil because it is thicker and has more body.

QUES. 8. Who packs the boxes on your engines, the engineers or shop men? All answer shop men.

QUES. 9. If shop men pack boxes, how long do you allow them to run before renewing or examining them; also do you have the same limit for all boxes on the engine? The answers to this question show a great difference in practice. Some examine cellars and tender boxes each trip and some once a week, one after engine makes 5,000 miles, others when reported by engineers.

QUES. 10. After a box has run its length of time or needs attention, do you repack it entirely with new waste or simply piece out with new waste, or do you take it all out of cellar or box, re-oil it and put it back in box again? Please give your method. The general practice seems to be, take down cellar and if packing is in good shape it is loosened up, re-oiled, and new waste added if necessary. One says "We take waste out of cellar and re-oil it, carefully picking it over and taking pains to take out any lump or gritty waste that may be in it, using only a little oil and adding more soaked waste." Your committee are of the opinion that the last mentioned practice is a very bad one, as taking the waste out of cellar and picking it to pieces has a tendency to bring some of the grit or sand collected to the surface or against the journal, causing a hot box. If waste is taken out and mixed up, it should not be used again for packing.

QUES. 11. Do you use any other lubricant than oil for packing boxes on engines? Nearly all answer "No". Several use a little valve oil if journal is hot. One uses hot box compound if a box shows signs of heating. One uses graphite with oil on hot journals.

QUES. 12. How often do you renew the packing on top of boxes, and

what means do you use to prevent dirt getting on to journal while doing the work? Some change packing on top of boxes every three weeks, but the majority renew it only when it becomes hard or dirty from accumulation of dust, cinders or coal. In changing this packing some lift the waste carefully and put plugs of wood or cotton waste in oil holes, clean off the top, then take out the plugs, run a wire in oil holes, see if clean and then repack. Some clean top of box with air, blow out oil holes and then repack with new waste.

QUES. 13. Do you use any trimming in addition to waste on top of driving or engine truck boxes? All but one answer "No". One uses syphons of woolen yarn in driving and engine truck boxes.

For further information your committee begs leave to present some of the letters or parts of letters received in answer to circular letter of questions. One says: "I will say that in order to pack a journal box or cellar, the waste should first be pulled apart so as to separate and open up the fibres and then soaked in oil for at least 24 hours. Before it is applied to the journal, box or cellar the surplus oil should be allowed to drain from it, for if applied when soggy with oil it has no elasticity and in a short time settles away from the journal. It is also true that when the packing is soggy with oil it occupies so much space in the cellar or box that as soon as the surplus oil flows from it, which quickly occurs, there is not sufficient packing left in the box or cellar to keep it in contact with the journal."

"When with a gentle presure of the hand oil can be forced from the packing, it has oil enough in it, and as long as it is in that condition and in contact with the journal, the latter is just as well lubricated as though a gallon had been squeezed out of it into the pit or onto the ground."

"In packing driving boxes or engine truck cellars, care should be exercised to have each corner of the cellar well filled and the packing, which previous to its application had been thoroughly soaked in oil, should be elastic enough so that it would come considerably above the upper edges of the cellars when the pressure is removed from it. By that means you insure its remaining in contact with the journals a long time, and the surplus oil applied above will keep it saturated."

"I believe the best packing for journal boxes and cellars on the market is the Perfection Journal Box Packing. It is about 65 per cent. woolen waste and has enough elastic fibre in it to insure its being kept in contact with the journal. Next to it, woolen waste is the most elastic. Cotton waste, while lacking in elasticity, has excellent capillary qualities, and when kept in contact with the journal gives good results. It should always be used on top of driving and engine truck boxes as owing to the closeness of its fibre it keeps the dirt out of the oil holes, and allows the oil to feed down more gradually than woolen waste."

"To sum up, waste intended for packing should be well pulled apart. It should be allowed to soak for at least 24 hours. It should not be applied in a soggy condition. It should be a rule to have cellar packing always kept in contact with the journal. When an engine is jacked up, or any other

work done which will disturb the packing, it should be inspected before sending the engine out."

Another says: "The art of packing boxes and kind of waste used depends largely upon the person doing the packing, also condition. For my part, I think good judgment is the most essential, as laying down rules and giving certain instructions in regard to packing without the person or persons using good judgment will not prove a success, especially in service."

"The kind of waste used on our road is woolen, which is used in all boxes on locomotive, both in driving and engine truck cellars, also tender oil boxes and sponging for top of boxes, which is used summer and winter alike."

"We prepare our packing by placing 50 or 75 pounds of waste in a tub or can suitable, adding oil sufficient to cover the waste and letting it soak until used. We then squeeze the oil out of waste using our judgment in not getting waste too dry, while at the same time leaving enough oil in waste to insure good lubrication. In packing driving box cellars we take a large hand-full, picking out all pieces of foreign substance that might prove detrimental to a cool running journal, placing packing in cellars so that the fibres of waste run crossways with journal and pressing down and putting in waste enough so that when cellar is in place the waste will press against the journal like a sponge. The same kind of waste is used in packing all parts of engine and tender."

"In packing tender it is necessary to take a large piece of waste that has been soaked in oil and twist it in a roll not too tight. Place it under journal and with packing iron push it to back end of box. This acts as a dust guard, also prevents oil from running out of back of box causing needless waste. The box is then packed by placing the rest of waste under journal with packing iron, care being taken to keep fibre of waste running crossways of journal until the box is filled within about ¾ inch of top or centre of journal. A layer of waste soaked with oil is then twisted and run lengthwise of journal on each side of box, also a piece at outer end of journal partly or pushed under collar so as to keep it in position."

"Boxes and cellars are packed by shop men in back shop, and by a man especially adapted to the work in engine house."

"Engines in passenger service are packed every 7 to 10 days. Cellars are taken down and waste loosened up, oiled and a little fresh added."

"No other lubricant is used in packing boxes and cellars with the exception of plumbago and graphite, and we have about discontinued its use."

"Packing is renewed on top of boxes when it becomes dirty, full of cinders, or decayed. Plugs of cotton waste are inserted in oil holes. Boxes are cleaned and rinsed off with water, plugs are then renewed and fresh packing put on."

Another member makes the following answers to the questions in circular letter:

"Question 1. Wool waste in driving, engine truck and tender boxes."

"Ques. 2. We find wool waste the most economical to use in all boxes having the least trouble with it on the road."

"QUES. 3. Use same waste on top of driving or engine truck boxes. Change oil only. Our summer oil is changed for winter oil Oct. 1st. Winter oil is changed for summer oil May 1st., using wool waste the year around."

"QUES. 4. We use no waste for packing that has not been in soak at least 48 hours."

"QUES. 5. Pull waste apart and get all hard knots and bunches out, and lay it in cellar as evenly as possible."

"QUES. 6. We use the same method for driving and engine truck cellars. We aim to not get waste in tender boxes higher than centre of journal, pushing waste well back to end of box and avoid the crowding of packing in box."

"QUES. 7. Use Galena engine oil for driving and engine truck boxes, and Galena car oil for tender truck boxes. Use the car oil for tenders as it is cheaper. Use car oil on all switch engines for engineer's use as well as packing all boxes."

"QUES. 8. Pick out a good man that has been working as helper in machinist gang and educate him in the proper manner to take care of waste for packing purposes and proper manner of packing and oiling cellars and boxes, also in taking waste off top of boxes. Have a man of this kind at all terminal points. Previous to adopting this plan machinists did all of this packing, and hot boxes was the rule not the exception. Now we only have an occasional hot box. We find that machinists are very poor men to intrust the packing of cellars to. It is quite a trick to pack a cellar properly and requires experience and good judgment. Another but less important reason is, we can get better results with a 17½ to 22 cent an hour man who does better work than a 30 or 35 cent an hour man."

"QUES. 9. Passenger engine driving and engine truck cellars are examined every trip and if need oil or packing it is put in, if not, cellars are pushed back in place. Tender boxes are oiled every 10 days and brasses examined every two weeks. Freight engines are only oiled or packed when reported."

"QUES. 10. Piece out. If waste looks worn, take out and renew. Here is where nice judgment comes in and where experience counts."

"QUES. 11. Nothing but Galena oil."

"QUES. 12. When reported, or when Engine Inspector thinks needs renewing. Have feeders in holes. Take off sponging, then blow off top of box with air or steam, pull out feeders, examine same and if they need renewing rewind with candle-wick."

"QUES. 13. Use feeders made of light copper wire and wind with candle-wick. These are put in oil hole, an easy fit, pushed down on journal, then draw back about one-half inch and bent so that it will not work down on top of journal."

"At all terminal points we have two large vats made out of galvanized iron. One vat is used for soaking and the other for draining packing. Every morning waste is taken out of the soaking vat and put over into the drain tank.. About one foot from the bottom, inside of drain tank, we put a 3x4

netting; close to bottom of tank is a plug for draining the oil that settles from the drained waste. This oil is used again for soaking waste. We aim to have waste in soak as long as possible before putting in drain tank and no waste used that has been in soak not less than 48 hours. This part we are very particular about. In taking waste out of soaking tank we take it from the bottom. In taking waste from the drain tank we take the bottom waste as waste on the top in drain tank, if left in drain for any length of time, say over 12 hours, becomes too dry. If waste in bottom of drain tank holds too much oil we do not take it out but take that farther up. We do the same with our packing for cars. On freight cars we use cotton waste, on passenger cars wool waste. But all packing must be left in soak at least 48 hours. We have one man days and one man nights to do all the packing and oiling in roundhouse. This man is generally taken from the machinist gang where he has been employed as helper and educated to do the packing and oiling. If a cellar is reported packed, he takes it down and examines packing and if in his judgment it only requires oiling he oils, if needs packing, he repacks or renews. On passenger engines he drops end of cellar each trip and feels of waste. If he finds it requires oiling, he has a small squirt gun that holds less than ¼ pint (this squirt gun has a small pipe attached bent on one end so as to enter cellar) which he inserts and distributes oil over the surface of packing. After a little experience he becomes so familiar with the feel of the waste's surface that he can tell by merely putting his hand in cellar whether it requires oil or packing. We disturb the packing as little as possible. Some cellars we have to take both cellar bolts out and draw down cellar in order to examine condition of packing, but most all of our cellars can be examined by taking out one cellar bolt. When any engine arrives in all covered with sand or dirt from being in a sand or dirt storm all cellars are taken down, packing examined and renewed if necessary. All packing on top of boxes is taken off and used for firing up. All feeders are taken out, box raised off journal and top of box, oil holes, hub and journal thoroughly washed off with steam. We find this pays. By having an assigned man do all the oiling and packing and look after soaking and draining of waste, we get fine results. Our engineers do no packing, only those that are away from terminals on branch runs. We use as little free oil as possible and find the small squirt gun a great saver of oil. The Traveling Engineer should watch the soaking of waste and also the draining of same, as waste that is in drain too long is no more good than if we use dry waste and pour oil on it just before using. I never visit a terminal that I do not inspect the soak and drain waste tanks, also get under engines with the packer and see how he does his work. Find that it pays. Changing from winter to summer and summer to winter oil at the proper time should be looked after carefully, as winter oil used in summer is the cause of a great many hot boxes. The same may be said of summer oil, as if used in winter it gives trouble."

To sum up briefly: this committee are of the opinion that all waste should be pulled or picked apart thoroughly so as to separate and open up its fibres before being soaked in oil. All waste should be soaked for at least

24 hours and then allowed to drain before using, as if it is not allowed to drain before using it will be entirely too soggy and if cellars or boxes are packed with waste in this condition it will only be a short time until the surplus oil runs off and then the waste will drop away from the journal, where on the other hand if the waste is drained (until by a gentle pressure of the hand you can squeeze some oil out of it) before using, it will retain its elasticity and remain up against the journal; it will also retain enough oil for perfect lubrication. We also are of the opinion that care should be taken to never allow packing to extend along the sides or end to a higher point than the centre of the journal. Should it wind up on side of box or cellar against the brass, care should be taken to remove all the packing that is above the centre line of the journal, as experience teaches that a good many troublesome detentions are caused by small particles of waste being drawn up under the edge of the brass. Or should some of it become hard, due to this tendency to wind, all such hard packing should be removed, as when in this condition it not only fails to convey oil to the journal, but actually in time becomes hardened and glazed, the effect of which is to wipe or scrape off any oil that may reach the journal from the forward part of the box, and in a short time will result in heating of journal. One of the most essential points in the care of boxes or cellars is to keep the waste in an elastic condition. Wool waste seems to give best results in cellars and tender boxes owing to its greater elasticity, but it is thought that cotton waste gives better results on top of boxes; owing to the closeness of its fibre it does not allow the oil to pass through as freely as it would if wool waste were used. For the same reason it also prevents dirt from passing down to oil holes in top of boxes. Still this is a matter in which no hard rule can be laid down, as the climate has considerable to do with it. In the northern parts of the country in winter it is advisable to use wool waste on top of boxes, from the fact that this closeness of fibre in cotton waste will not allow the oil to pass through it as freely as it should.

Respectfully submitted,

D. Meadows, Chairman.
W. C. Hayes,
J. J. Watson,
J. F. Walsh,
J. C. McCullough,
Committee.

The President: Gentlemen, Mr. Hedendahl would like to have Mr. Wilden and Mr. Keith meet him in parlor "C."

Secretary Thompson: Mr. President, the committee on arrangements wishes me to announce that there will be a concert at the Armory tonight for the members, their ladies and friends. Mr. Bryant, of the Detroit Lubricator Co., has the tickets and he will be glad to furnish you all you need.

The President: Gentlemen, you have heard the report read by Mr. Meadows on the very important subject of "How to Pack Boxes and What is the Best Kind of Waste to use to Insure the Most Perfect Lubrication of the Bearings of our Engines," and it is now open for discussion. Mr. Walsh would you be kind enough to open this discussion?

J. F. Walsh (Galena Oil Co.): Mr. President, I do not believe I can add anything to the report of that committee. I think they have covered the subject very nicely, and I do not hesitate to say for a moment that Mr. Meadows is entitled to a great deal of credit. I cannot add anything to it, and I think the question has been covered very thoroughly.

P. Miller (M. C. Ry.): I am of the same opinion as Mr. Walsh, the ground has been covered entirely.

C. H. Hogan (N.Y. C. & H. R. R. R.): I think the committee has made a very good report, but I judge from the report that the engines are hung from the frame, in considering cellars of engines that are hung below the frame that cannot be moved. That is a question of importance and one that has given considerable trouble.

The President: With engines that are hung below frames how do you get at the cellars?

Mr. Hogan: There is a plate inside the cellars which is in two sections. Owing to the opening being about two inches through the structure, it divides the cellar and the waste has to be removed entirely and the doper has to be very careful that he removes it all from the back and sides of the cellar; most of the trunk lines are running engines of that description. Of course the report of the Committee does not cover that. It simply speaks of engines equipped in such a manner that the cellars can be dropped and oiled or the waste removed. The space between

the dividing line in the cellar and the journal is only about ¾ in. at the greatest, and a man has to be very careful in shoving waste over in back that the syphon of waste in the cellar is next to the hub of the wheel, which is very important.

Mr. W. G. Wallace (C. & N. W.): Mr. President and gentlemen, I do not know just what method they would use to pack a box to run five thousand miles without looking at it and keep it running cool. We find that in order to avoid hot boxes on a great many trains that it is necessary to give the cellars of our tender trucks attention every five or six hundred miles. If the sponging is all right in the cellars, of course we have nothing to do with it, but as a rule we do find that they require sponging and oiling from five to eight hundred miles on our fast train engines. Our engines that are under-hung have plates on the cellars that can be taken off of the side and the new packing applied. It seems to me that the report covers the ground completely, and what is left for the members to do on their return to their respective divisions would be to do what is best to meet the requirements of the service. Recommendations when packing boxes are useless unless they are carried out. The man that packs the boxes is not given a great deal of attention, not as much perhaps as he should be. The foreman will come around, "Well, how is she, have you got her all right for tonight?" "Yes sir, I packed her up." That is the way it goes. I believe that man soon becomes an expert in that business, and it is well to place the responsibility for a hot box on the man who is taking care of it; that is, if an engine came in and the inspector looked that engine over, she goes out and develops a hot bearing which causes a delay, the inspector should be responsible for that delay. I have nothing to say on this hot-box question because we have had that up and have had our troubles with it, and I have received some valuable suggestions from the representative of the oil companies which have proven quite a benefit, so far as we have been able to put them into effect.

Mr. Langdon (Union Pacific): I would say the report covers everything very fully. I believe a good deal of our troubles is caused by the round house inspectors not looking after it carefully; the most of the trouble has been in packing the boxes too tightly.

We watch our oil and waste pretty close, drain it and not let it get too dry, and if it is a little too dry at the top we take it from the bottom of the soaking tank. Sometimes we catch them taking waste that is too dry; we are now putting the waste in three rolls and pack them so there is very little oil coming out of the waste. In regard to this woolen waste and cotton waste, we find that cotton waste is all right in summer and woolen waste in winter. I believe the woolen feeder in the top of the box is better than the cotton feeder; outside of that I think the report is pretty complete.

D. Meadows (M. C. R. R.) Mr. President, for the information of Mr. Wallace I would like to call attention first to the fact that one man mentioned five thousand miles, but on the road that I represent we attribute a great deal of our success to the care of the driving boxes. Now we have engines that are making thirty-two hundred miles in seven days, and the instructions are that those cellars are to be looked at every seventh day. Those cellars are simply taken down and if found in good condition they are simply oiled and put back. Of course if we find the waste is getting very hard it is renewed, but as a rule they are simply oiled, and I am satisfied that I am safe in saying that we have not, in our passenger service, had three hot driving boxes in the year 1900. There are two trains on the road that make 227 miles with only one stop. Of course, there is another thing that I must mention in this connection, and that is that our engineers are supplied with what we call a squirt gun—something on the order of what we mention in our report. The engineer can insert that in the cellar and inject perhaps a half a gill of oil in each cellar.

Mr. Langdon (Union Pacific): Boxes on our passenger engines are examined every trip, and we pack them if necessary, which they hardly ever do, we oil them with the squirt gun; on our freight engines we oil them about once a week.

W. O. Thompson (Hancock I. Co.): I took care of driving boxes for several years, and had a good deal of experience as well as trouble, until we adopted the plan of packing driving boxes every thirty days, and engine trucks every fifteen days. In connection with this matter one of our members wrote to the com-

mittee, but it came too late to be included in the committee report. The contents of this letter will probably be of interest, and with your permisson, Mr. President, I will read it.

Mr. Thompson then read the following letter:

PACKING DRIVING BOX CELLARS, BY J. S. MARTIN.

In connection with the paper on best methods of packing driving box cellars, I wish to venture a few remarks on this subject, as I have had exceptionally good opportunities for observing driving boxes under all conditions of service, and I append you a few statistics on the matter which may be of some value. These statistics cover a period of six months during the hottest and dryest part of the year, in the hottest and dryest part of the south-west. This report covers performance of 78 engines, and is part of a record of number of driving boxes reported packed for six months. These records were kept on a large form devised for this purpose. As all these engines were pooled the idea was to decrease the number of hot boxes, and also to make a saving if possible on oil and waste, and we accomplished both.

Round-house men engaged in this class of work were instructed before hand in best methods of applying fresh waste, and in oiling the cellars. There was no packing removed from cellers unless found burned or charred. Cellars were packed lightly and we aimed to get just the right amount in the cellar to enable waste to feed oil up to the journal. The waste was prepared before hand, six pints of oil to one pound of waste well saturated and placed on a screen until wanted.. In applying packing to cellar, waste was put in in three rolls slightly twisted and placed parallel with the journal. Packing placed in this manner prevents lateral in driving wheels from working waste out of the cellar. Cotton waste was used for tops of boxes, as it has more body, is more compact and will retain its oil longer, thereby feeding oil to journal more gradually. Wool waste will feed its oil upward which is proper when used in cellar, but when used on top of box will simply let its oil through and bearing gets the oil all at once.

Driving box wedges were carefully adjusted. It is known that a wedge up too tight will cause same to stick and heat the box. It is also a fact that a wedge not tight enough to stick will sometimes cause the box as it moves in jaws to pinch the bottom ends of brass against journal and cause box to heat.

Babbitt was used in the brass to break the density of the two metals. As to be expected we had cases where babbitt was melted out of brass, and in handling a case of this kind we adopted a method for rebabbitting a brass, which considerably

lessens the time an engine is kept out of service and also saves labor.

Instead of dropping wheel to re-babbit brass, the cellar is removed from box to be worked on, and a jack placed underneath and box raised an inch or more off journal, and any babbitt left in grooves can be easily chipped or burned out. A piece of paper laid on journal keeps babbitt from getting chilled, and a piece of tin laid above this makes babbitt smooth. When job is completed, hot babbitt can be poured in groves by using putty to guide the hot metal.

In glancing over the attached you will note that nearly one-fourth of the boxes reported running hot were found on inspection simply dry, showing that in-coming engineer neglected to oil these boxes. This method of keeping records of driving box packing enabled us to handle a case of this kind with great satisfaction, as we know the condition of celler packing and could save the time of one man pulling cellar down for no purpose.

An engine run in a pool by men who have an honest interest in the engine will experience an uneasy feeling concerning driving box packing when they show a tendency to warm up, and as he has no way of knowing when they were last packed, the familiar "Pack all driving boxes and engine truck cellars" will appear on the work book. This is both expensive and annoying, and can only be avoided by some intelligent system of records, both of cellar packing and wedges.

A record of each individual driving box will bring to light deficiencies not thought of, such as brass improperly fit, or too much hub friction, &c., and a box once hot can be handled by this method with greater satisfaction, or in other words a box giving continual trouble can be humored until it will run cool.

In 98 cases the packing was found insufficient and had settled away from the journal. It appeared clearly to me that the waste put in these cellars was too highly saturated when first put in the cellar, the waste does not need to be soaked when put in, in this condition the weight of the oil will settle the packing away from the journal. Waste when properly prepared and taken off a screen will in addition to the oil received from top of box furnish all lubrication required. A practice of some engineers in stirring up packing on tops of boxes with spout of the oil can, to get the oil to oil hole should be avoided, as any dirt or cinders which might lodge on top of box will surely get through the oil hole to journal.

A device made of one-quarter inch pipe turned to proper angle with globe valve in same, and coupling attached to couple to shop air, should be used for cleaning tops of boxes, and oil

holes should be thoroughly blown out and clean waste applied. In breaking in new engines, great care should be exercised by engineer handling the engine in watching the journal bearings. The practice of walking around an engine and feeling of the driving wheel hubs, is not always a safe way to detect a hot bearing. It is known that an ash pan bearing on an axle will create a friction, and radiate heat to the hub, but the box will be much cooler.

I have seen new engines making trial trips, and have babbitt started in brass, and I have laid my hand on the hub, and found it comparatively cold, but on touching the box almost burn my hand. This surely is not hub heat, and fully demonstrates the importance of feeling both the hub and the box.

In conclusion I might say that there was not a foot of cold water pipe to any of these driving boxes used on these engines.

Record of driving box cellars reported packing for six months beginning May 1st, ending October 31st, 1899, condition of cellar and cause for box heating as follows:

| | |
|---|---|
| Packing found O. K. and in good condition | 99 |
| Insufficient waste in cellar | 98 |
| Packing dry | 63 |
| No babbitt in brass | 24 |
| Dirty packing | 17 |
| Fire falling from ash pan | 17 |
| Journal scratched and rough | 9 |
| Packing worn out | 5 |
| Brass loose in box | 3 |
| Oil holes stopped up | 3 |
| Cellar packed too tight | 2 |
| Cellar bolt lost out, letting cellar down | 1 |
| Cellar bursted letting packing out | 1 |

Lewis Gleason (Galena Oil Co.): Mr. President, I do not know as I have anything to add; it does not make any difference how many recommendations are made in regard to packing boxes; every man has his own ideas of packing and he will carry out that idea; while we know that improvements can be made and no doubt they have been made in a great many engines, at the same time it seems to me, Mr. President, that the proper place to begin to prevent hot boxes is at the foundation; that is to have the mechanical work done properly on the start; now in looking for the causes of hot boxes it is well enough to inspect the mechanical

part of the work before you go the oiling part of it. That is all I can say.

Martin Monroe (C. O. & G. R. R.): There is no subject I could feel more interested in; I have had more hot boxes to the square inch than any other man in this country; but for the last six months I have not seen any hot boxes. The last six months of '99 I believe we had a hot box every day; but I think if you will look for the cause in the mechanical construction of the engine and not for fault in packing you will come nearer to locating the trouble; I have seen boxes packed with soap, greese, and all kinds of oil, still they would not run cool; while I hear they run on other roads very successfully but the ones on the Rio Grande, why, they would get hot standing still, anybody could go out on a passenger engine that wanted to, the other feller didn't want it; they were packed in every conceivable way, but would not run cool. While in the delightful state of Arkansas there is not much dust and the boxes run good—in fact I do not know what a hot box is.

G. W. O'Neal (N. Y. O. & W. R. R.): I think the report of the Committee covers the ground very thoroughly in regard to taking care of boxes; we have had very little trouble in that respect for the simple reason that we try to use good material for our journal boxes, and use it quite liberally, and I think that that has gone a great ways to overcome our hot boxes. We use on our passenger engines a water pipe and water taken from the tank leading over to the journal bearing, and we run it on the journal, and I think that that has a great tendency to help us out of some of our difficulties. We have adopted a sliding plate on the cellar and they are put on when the engine is in the shop and we keep gradually pushing up that plate, keeping it close to the journal so that if the bearings wear and the cellars drop away we slip that plate up so the packing is kept in the cellar. On our freight engines we do not pack any boxes unless they are reported by the engineer; if an engineer coming in finds that there is a box that is showing any indication of running warm, he reports it and it is packed and the packer who does that work, if he notices in the meantime on the same engine any other cellar that looks as though it needed taking care of, he does that. But the cellars on

our passenger engines are examined every three hundred miles, we just drop the end of the cellar and examine the packing, and if it is all right we use one of those squirt oilers that Mr. Meadows spoke of, and insert a little oil on the top of the waste and put it up. If the packing is rolled up we pack that back in place or do anything we may think needful; that is the way we are taking care of our driving boxes and engine trucks, and we have but very little trouble.

T. J. Bullock (C. & O.): I think this an excellent report, and I do not see that I can make any recommendations. We are carrying out a practice on our road very near like that recommended by the committee, and we have very few hot boxes on our road; I can safely say 80 per cent. less in the last year since we have been giving it special attention. I attribute a great deal of our success to Mr. Walsh who took a great deal of interest there in undertaking a new method of taking care of boxes, and I followed it up very closely and had it put in practice, and we have had good results. We have vats that we prepare our waste in, and we pack our cellars with new packing. I see that was not recommended by the committee, but we have been having very good success with our large passenger engines. On each return trip of our heavy passenger engines the cellars are repacked or re-oiled. On our freight engines we never pack the boxes unless they are reported by the engineer; we endeavor to run our tank boxes about 1500 miles before we oil them, and then no new packing is added unless it has been hot or has been reported. I think the committee's report is good, and I do not think I could say anything that would add to it.

Wm. Walsh (Galena Oil Co.): I do not know that I can add anything to what has already been said. Mr. Wallace went over the system of taking care of boxes on the North-Western as thoroughly as one could, and as I have the pleasure of looking after the North-Western Railroad with Mr. Wallace I could not very well say anything but what has been said by him. I may say though, that my success in running driving and truck boxes and tank boxes is not in the renewal of waste, but it is the keeping of the waste in contact with the journal; in my experience as a locomotive engineer and as an oil man, representing the Galena

Oil Company, I never recommend the waste to be removed from the driving box cellars unless the box was warm; one great mistake I think that is made by round house people is the throwing away of the packing that has been run in those cellars; we well know from our experience that the older the packing the more oil there is in it, but we also know that when an engine comes in running warm and is so reported by the engineer, that about the first thing that is done is to remove the old packing and have new packing applied.

I notice another thing mentioned in the report that I think is wrong, and that is the rolling of the waste. In the report read by Mr. Thompson a moment ago it calls for three pieces; those pieces are rolled or tied as it were. Now it appears to me that the object of applying waste to a car box, and in using a good quality, is for the spring of that waste so as the brass wears that the spring of the waste will keep itself in contact with the journal. Now if we take a piece of waste and we tie it, it would appear to me that we did away entirely with the spring of the waste, and I think it is a mistake. The majority of the men prefer woolen waste to the cotton waste. There is only one thing in favor of woolen waste and that is the spring; we know full well that it costs more than the cotton waste. The only thing we want the woolen waste for is that it will keep itself in contact with the journal; if it did not we might just as well save five or ten cents a pound and use the cotton waste; it would seem if that is what we use the woolen waste for that it is a mistake to tie it. If we would give a little more attention to our driving box cellars and our truck and tank cellars, instead of applying oil to them, if we would take the waste out and pull it apart sufficiently to make it a little fluffy and have that spring in it, hot boxes would be reduced.

C. A. Crane (A. T. & S. F.): I think the ground has been very well covered. I agree with Mr. Walsh that it does not make any difference how well you pack boxes, how carefully you pack them, if they are mechanically imperfect they are going to run hot. We have had a little experience in that line lately. In changing our power from New Mexico and Arizona into Illinois we found that engines that have been running very successfully

when we got a different class of power, although they were handled in the same manner, we are troubled with hot boxes owing to the mechanical defects which existed in these engines. The question of hot boxes is always with us. I think if all the recommendations are carried out as recommended by the committee and boxes are properly fitted with right kind of material, we are doing about all we can to overcome the difficulty.

Secretary Thompson: Mr. President, there has been a note handed in just now. Please announce to the ladies that they are invited to take a trolley ride west over the Consolidated Electric Line for a visit to the Chewing Gum Factory, the largest in the world. Special car to leave public square at 1:30, leaving the hotel at 1:10. Will you please inform the ladies of this?

The President: Mr. Wm. Walsh, I will appoint you to notify the ladies of this trolley ride.

W. B. Galivan (B. & O. S. W.): It would seem useless after all that has been said to take up any more time. The committee has certainly reported very fully, and I am satisfied that if we follow the suggestions that have been made our troubles with hot boxes will be reduced to a minimum.

C. B. Conger (Locomotive Engineering): There is one point which is not mentioned in the report that is very important; the cellars should always be fastened in the engine truck boxes so that they will be solid in the box. They fit loosely in the box and are usually fastened with half-inch bolts through a hole that is worn oval up and down so it is over three-fourths of an inch. When the engine is running the cellar works up and down with every jar that the wheel and journal gets. This soon packs the waste down even with the edge of the cellar and squeezes the oil out of it, leaving a space between the journal and the packing. This does not lubricate the journal; besides the dust and grit get in on top of the waste and possibly strikes the journal. This tends to make the journal run warm. If the cellars were fastened so they could not work up and down in the boxes, we would have less trouble with engine truck axles. As to the driving boxes, they carry a much greater weight per square inch of bearing surface than the engine trucks, and the driving boxes cannot move around as well to accommodate themselves to the rolling of

the engine on curves or uneven track. If an engine settles over to one side and twists the box out of line with the journal, that driving box is going to run hot at once. This is not always the case with truck boxes.

M. P. Cook (Cook Cooler Co.): I came here seeking light on this subject. It goes without saying that the mechanical defects will cause hot boxes. Journal boxes will run hot when mechanically imperfect; if they are mechanically perfect and they run hot then there is a lack of lubrication. Now the question to be considered is how to pack boxes, what kind of waste to use to get the most perfect lubrication on all of our bearings. There is a great diversity of opinion in reference to the kind of waste to use; one will use wool waste and get good results, another cotton waste and get results equally as good. The duty of waste is to store up oil and give it off as the journal demands it; it will call for it when a sufficient amount of heat is generated to reduce the density of the oil. Now what waste will hold the largest amount of oil and give it off in the most uniform manner? One may use wool waste, another cotton. I have attended some exhaustive experiments on that line when I was running an engine, and I found that cotton waste on the top of driving boxes will store up more oil. It settles down over the oil holes, when the friction heat of your journal generates it will feed that oil and your waste does not loosen up and let your oil run off. My experience has been that heavy fibre cotton waste properly put on top a driving box, as the heat in your journal increases your waste settles in place and feeds your oil off gradually. The disposition of that waste is to settle down over the oil holes; on the other hand, if you use wool waste it is the disposition of the waste to rise up and let the oil run off quickly. If you take cotton waste and put it in the cellars it will have the same effect as on the top, cotton waste will hold more oil than wool waste. If you will take the wool waste, make it one-third wool and two-thirds cotton waste and put it in the cellar your wool waste will hold your cotton waste up to the journal. Now the cellars that Mr. Conger speak of will run hot and it does not make any difference what kind of waste you use. When mechanically perfect you will find that a small amount of wool waste mixed with long fibre cotton waste

put in the boxes cross-wise but so the fringe will run up; you would not think of using an old stocking or a wool wick in a lamp, if you did your lamp wick would char for you would get imperfect lubrication; now it is a self evident fact that we get the best light from a cotton wick; hence, use woolen in the cellars and cotton waste on the top of your driving boxes and you will get the most satisfactory results.

Mr. Walsh spoke of old waste. When a journal is lubricating you have got to have from one hundred and forty to one hundred and sixty degrees of heat for perfect lubrication. Now I have heard some reports from Prof. Goss and Prof. Johnson, of the University of Wisconsin, who will be here this afternoon; it is a serious question and we have asked them to make various tests. Now take waste that has been in boxes—just as soon as your journal boxes get hot your oil evaporates, and I think if there are any Galena Oil people here they will tell you that when you get up to three hundred and fifty to four hundred degrees of heat the lubricating part of your oil is evaporating. Now you take waste that has been used for any length of time and you will find it is soggy, sticky; you can bunch it up together and it will stay there; now the lubricating part of that oil is gone, the residuum is there, you pack it back in the boxes and it does not distribute the oil. The duty of waste is to distribute the oil and hold it; if your waste has been in service so long that the oil has escaped and is filled with the residuum of the evaporated oil it will not give you good service. When you find waste in that condition, take it out and put in new.

F. P. Smith (Hancock I. Co.): One great trouble nowadays is the distribution of weight; that is the difficulty that Mr. Monroe speaks of on the D. & R. G. engines. On those engines the weight was not properly distributed, consequently they could not get oil enough on them to run them cool. Another difficulty is that a great many of the railroad people disregard the advise of the brass people and make their own brass or furnish inferior brass to the locomotive builders in building new engines, which causes a great deal of these troubles in large engines which can be attributed to those two points. In many cases where care is taken and the weight is properly distributed, if the brass men had the

proper formula there is no difficulty about journals getting hot. I have in mind some very large engines which have been built this year. They have been petting them for four months and they have never made a successful trip, notwithstanding the fact that there have been seven barrels of Galena valve oil used on these engines each month for that length of time. That whole trouble is due to the formula of which the brass is made. There was one maker of brass goods specified for those engines, which cost three cents more per pound than it would cost them to make and the cheaper brass was used; consequently they have been a continual source of annoyance and delay. It has now come to a show down, and the engines have to be sent back to the works and the brasses taken out and renewed with the material specified originally. So a great deal of this trouble comes from poor material and imperfect distribution of weights.

L. D. Gillett (N. & W.): The question of hot boxes is like what has been said, it has got to be governed by circumstances; the conditions in one place will not apply in another. It has not been a question so much of hot boxes but of how little oil you could use, how near you can approach a hot box without having it, and we have approached that point; we have found that a good deal depends on the sponging, largely in preparing that sponging; we have had the cotton waste and wool waste mentioned. I may say from my own experience I have run cellars like Mr. Conger has mentioned with a one-fourth inch cellar bolt in a three-fourth inch hole and have run it successfully and did not use any waste at all. I have used horse hair which made itself into a syphon and took the oil from the bottom of the cellar and up against the journal. Yet, of course, we could not afford to use horse hair very extensively, we know that. In the packing of our driving boxes on our heavy engines we found several points that are worthy of note. We began at the top of the box, we kept the waste clean, we kept it alive but kept the oil holes clear, we went to the cellar and we did not prepare our sponge for the moment, we kept it continually prepared, we have a receptacle for that purpose; our waste is thoroughly saturated when used; we found in doing that that we had better results. Another trouble we had, and I presume everyone else has had it, and that

is that we have hub friction. In many cases where our large engines got hot, it was not caused by bad packing in cellar or lack of care on the top of boxes, but it devolved itself into the care of the engineer in oiling regularly between the hub and the box. After we got our men educated in that line, our hot boxes got to be a thing of the past, and it is very seldom that we now have a hot box.

Mr. Webb (Michigan Central): As probably the youngest man of the order and a man who has but recently accepted the position of Traveling Engineer, I do not feel that I can have anything that would be of any great merit to offer. However, I think Mr. Gillett has sounded what might be termed the key note, and that is the interest which men generally take in locomotives. The time was when the locomotive was considered the finest piece of machinery that was operated, and the locomotive engineer was a king; the locomotive service generally and the engineers' department was the pet department; if there was anything that the department wanted they had it, but today it is different. If there is a reduction in force it is the locomotive department that gets it, and they get the pinch here and there. The cause is that today the average man in the locomotive services cares but a little bit more for a locomotive than he does for a wheel barrow, and the effect is far reaching. If you take the engine today, put it back where it was thirty years ago, let the engineer wear a white shirt if he wishes, let the locomotive be the one object of interest to all men on that system, and every man will be bound to do his utmost to make that machine a success, and with that condition prevailing it cannot help but be a success. The time was on the M. C. R. R. when the pinch bars that were used in putting in driving springs were covered with leather so as not to mar the paint on the wheels, the man whom I fired for told me. If there is anything there nowdays it is covered with an accumulation of dirt. I was always an advocate of cleanliness. Put the locomotive back where it was, raise it in the estimation of the people who operate it, the people who work around and about it, and if necessary put a plug hat on the engineer, and it will pay, there is no doubt about it. The man with a good suit of overalls and clean tie will command more respect and get better service

than one who will go around in old dirty overalls. Raise your engine away from the plane of the wheel barrow, and in time your engine will come up and you will get the very best service out of every man who works around that engine; if he has any good in him you may depend upon it cleanliness will certainly bring it out.

The President: If there is nothing further on this subject, a motion will be in order to dispose of it.

Mr. Meadows: There is one part I would like to touch upon, it seems to me that it should not go by without calling attention to the fact that so many boxes being reported running hot and on examining them they were found dry; this was evidence that the engineer in bringing the engine in had neglected to oil the engine; I believe that if an engine came in with a hot box we would expect to find it dry from the fact that it was hot.

Eugene McAuliffe (International Correspondence School): As a member of this Association, I make an appeal for some means of getting into the locomotive driving cellars without going to the labor of pulling out cellar bolts and possibly pulling down the driving cellar on the road. While at the World's Fair in 1893, I noticed an exhibit of a moveable plate, and the man in charge of that exhibit explained that the plate was fitted to the driving cellar with a short joint held in place by two short set screws. It occurred to me that that is something that could be applied to every engine. Certainly the engineer should have some easier means of getting at the cellar.

I would suggest a plate that could be slid up and kept in close contact with the journal keeping the waste in its place and keeping the dirt out.

I have waited patiently for years for some man to take up that matter of protecting the waste by putting a plate on the inside of the cellar and making a mechanical appliance that would admit of easier access to the cellar.

Geo. W. Wilden (Plant System Rys.): In speaking of driving cellars; this matter was taken up by the Plant System; we had some heavy engines that it was impossible to get at the cellars on the road. We experimented with them and later the subject was written up in Locomotive Engineering. A cellar

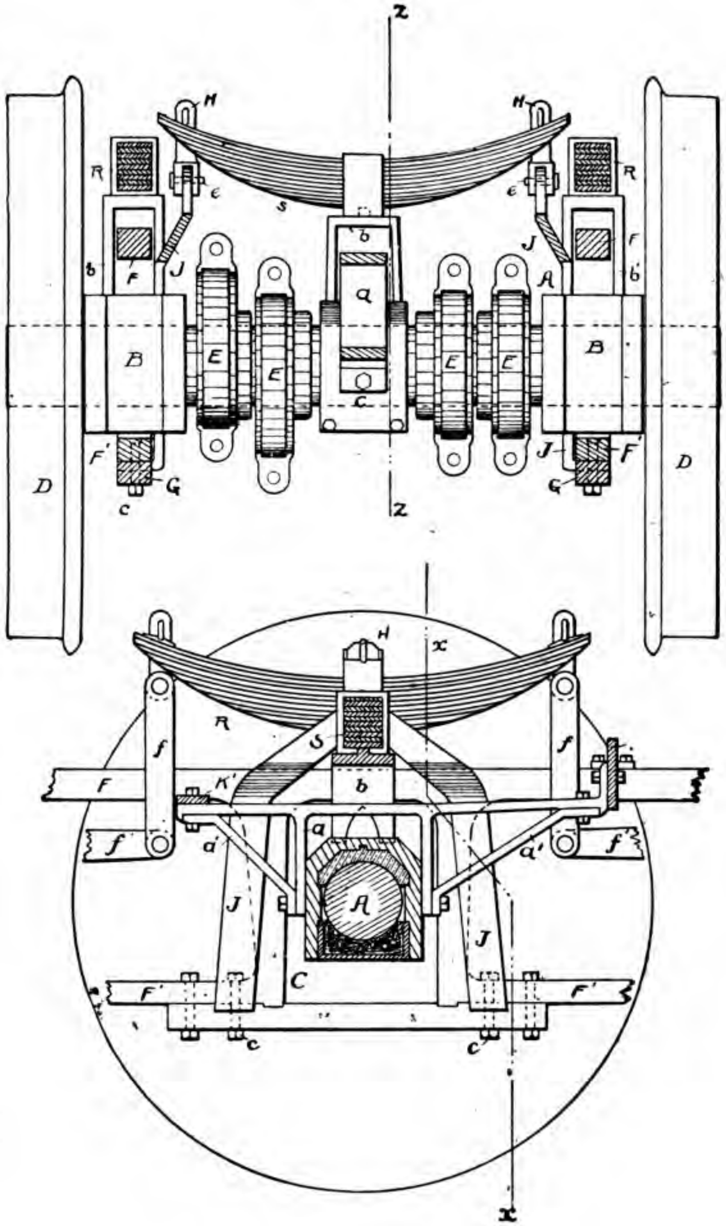
can be packed without the use of the wrench or screw driver, the plate being held in place by a leather to be put on wedge shape face at the bottom.

I thought I would bring this matter up in relation to Mr. McAuliffe's talk to show that it can be done, and done easily without any set screws. I am not in favor of any plate to cellar that requires you to take set screws out.

William Owens (Lehigh Valley): The last road I was running on we had a plate that you could shove up and had a leather between the plate cellar and opening in the end of cellar. In regard to the kind of waste—we experimented with cotton waste, wool waste, and everything else, and we had better results with a mixture of cotton and wool in the cellar; in the summer cotton waste on top of the boxes, in winter a mixture of cotton and wool, and find they produce better results than anything we have used.

F. M. Nellis (Westinghouse A. B.): A few weeks ago I had the pleasure of calling on Mr. McIntosh, Superintendent Motive Power of the Central R. R. of New Jersey, and he showed me a device that he was using on his heavy engines for keeping the waste in the cellar up to the journal and to distribute the oil to the journals, and it seems to cover the ground pretty well, and I think the committee might, with benefit, ask Mr. McIntosh to furnish a blue print of this device, for it certainly does nicely. I may say that Mr. McIntosh said his engines run hot until they got up this device, and that they haven't had any trouble since.

G. W. O'Neal (N. Y. O. & W.): For the information of the members, I would say that on our class R engines, which is a heavy engine that we had considerable trouble with them running hot and that we put on a third journal bearing on the main and rear driving axles in the center of the axle, which took off about 10,000 pounds off the bearing of that journal, and it has been a complete success; I have, I think, a blue print with me if anyone wishes to see it. Mr. McDonald, of the Pennsylvania R. R., was there on that road looking for information in regard to heavy passenger engines running hot and I showed it to him, and he was very much pleased with it.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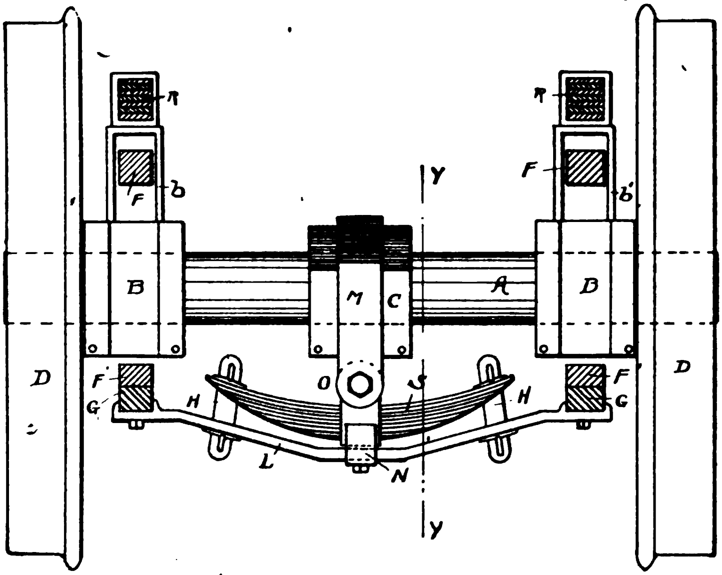
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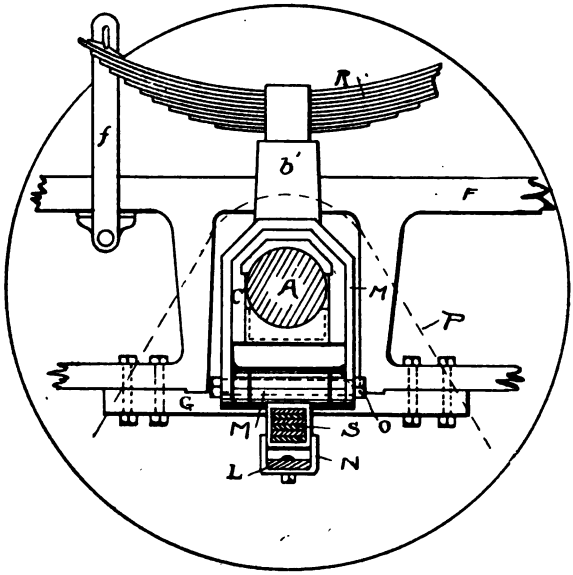
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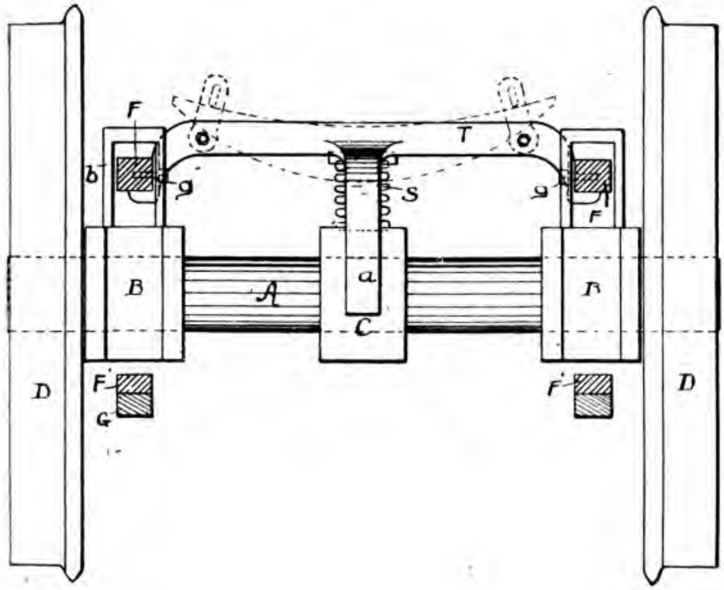
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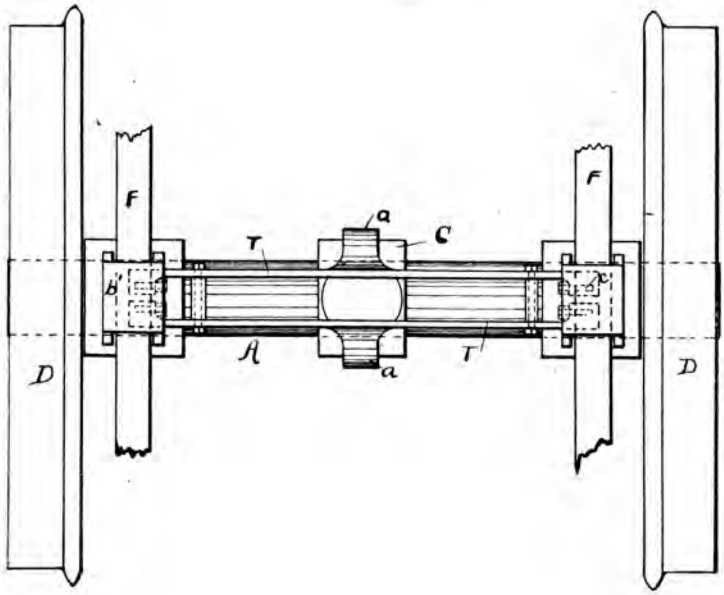
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F. M. Nellis (Westinghouse A. B. Co.): I move the discussion be closed and the paper accepted with thanks.

The President: It has been moved by Mr. Nellis and seconded by Mr. Miller that the discussion be closed and the paper accepted with thanks.

Carried.

The President: The committee of Traveling Engineers who will meet with the Air Brake Men is composed of W. G. Wallace, C. H. Hogan and C. B. Conger. I understand Mr. Otto Best is chairman of the Air Brake Committee, and I believe he would like to meet these gentlemen this afternoon, as he wishes to return home this evening. One or two other members of the Air Brake Committee will be here today.

Otto Best (President of Air Brake Men's Association): My object here today is to meet with the committee appointed by the Traveling Engineers' Association. A committee was appointed by the Air Brake Men's Association to try and make arrangements for both of the Associations to meet at the same place and during the same week. This would afford anyone an opportunity, who desired to do so, to attend both meetings at the same time. My opinion is that it would be a good thing for both the Associations to meet together, and I would like to say to you as President of the Association of Air Brake Men, I give you all a cordial invitation to meet us in Chicago, April 30th.

The President: We have the report of the Auditing Committee, which the Secretary will read.

The Secretary then read the Auditing Committee's report as follows:

We, the Auditing Committee, have examined the accounts of the Secretary and Treasurer and find the same to be correct.

Respectfully submitted,

T. A. Hedendahl,
C. F. Keith,
G. W. Wilden.

Moved by Mr. O'Neil and seconded by Mr. C. B. Conger that the report be accepted and the committee discharged.

Carried.

C. B. Conger: I move we adjourn until two o'clock.

The President: Our closing hour is one o'clock.

F. M. Nellis: As the hour has arrived for topical discussions, I move we proceed with them, and if not that we proceed to the reading of the next paper.

C. H. Hogan: Before the committee appointed by the president to meet the committee from the Air Brake Men's Association, I notice they meet in April and we in September; who is to yield the time of meeting, and which is the most favorable time for both the Associations?

The President: As soon as we hear from the committee we have appointed, we will take that up with the convention and go over it. We are waiting now to hear from our committee on that subject.

Are there any questions under the head of topical discussions? If not we will proceed with the reading of the next paper. There do not seem to be any questions, and we will proceed with the next subject. If any of you gentlemen would like to have any questions brought up for discussion tomorrow, please send them in to either the Secretary or myself. Mr. Hedendahl, as Chairman of the committee on "The Proper Manner of Handling Air Brake Trains on the Road," will you kindly step up on the platform and read it?

Theo. A. Hedendahl (U. P.) read the report as follows:

## The Proper Manner of Handling Air Brake Trains on the Road.

*To the President and Members of the Traveling Engineers' Association:*

GENTLEMEN: The subject is one that has been frequently considered under various headings in the past, by this and other Associations, and it would appear that nothing new can be added to what has been so ably handled in the past; therefore the old ground will, of necessity, have to be gone over. But when taking into account that the matter is of most vital importance, not only to the railroad world but the public in general, your committee begs to submit for your consideration the following:

In the first place it is of paramount importance that the brakes, draw-gear, etc., be in proper condition on locomotives and cars, by giving same the attention required by inspectors and others whose duties it is to bring this matter to a successful issue, or the proper handling is not realized from the start.

By this is meant that before engine is attached to train the engineer has his air pump working with maximum air pressure pumped up, driver and tender brakes tested, to know they are free from leakage, have the proper piston travel, etc., that lubricator and air pump governor are in proper working order, that brake valve is in proper condition for the trip, and that before the train leaves the terminal the carmen and trainmen have tested all car brakes to know that the piston travel is within the proper limits and that no undue leakages exist; that all the brakes are cut-in, etc. When the final yard test is made after locomotive is attached to cars, the application must be made in the usual manner from the engine, (by the engineer if possible) who must note the operation from his standpoint, by noting the length of time required for equalization of train-line exhaust, to determine the approximate length of train line, and if in his judgment the operation does not indicate the proper conditions, he should make necessary investigations to determine the cause of the apparent irregularity before leaving the terminal point.

At any point where train has been separated for any cause, the following may be considered equivalent to the terminal test, to show the train pipe is open to the rear air brake car. After coupling up, a signal to apply the brakes will be given by the rear brakeman or conductor, who will note if last two or three cars apply; signal to release will then be given, and if those brakes previously examined release it will indicate that train-line is open the entire length of air braked cars.

### RUNNING TEST OF AIR BRAKES.

Owing to the vastly contradictory views entertained by different railway men, regarding the practicability and value of the running test after starting from terminal stations and other places where train has been parted, your committee does not feel justified in recommending this practice for freight trains in particular, but when this is the rule or prevailing practice on

freight or passenger trains, the rear brakeman should be located on the rear air braked car when pulling out from any station where this test is to be made, and when he notes the brake taking effect on this car, he should signal the engineer by suitable signal; the brakes should then be released at once and the answer signal given by the engineer's whistle.

MAKING SERVICE STOPS—PASSENGER TRAINS.

When making service stops, as at way stations, with passenger trains, the question of one versus two applications is of importance, and your committee would strongly recommend the two-application principle as a general rule, for the reason that very few passenger trains are now found whose average speed does not greatly exceed 30 miles per hour at the time when brakes are first brought into use in approaching a station, which when taking into account the fact that co-efficient of brake-shoe friction increases with decrease of speed, consequently the tendency to skid and flatten wheels is more apparent under the one application principle than with two or more applications; this, for the reason that under the one-application principle, the brake force is of necessity greater just before stopping than in the early stages of application; hence it is recommended that the first application be made strong in accordance with the speed at which train is moving; or in other words, graduate the tension of brake power as near as possible to the speed.

When the momentum of train has been greatly overcome and under control, release the brakes fully by leaving brake valve in release just long enough to force all triple valves to release position; then return brake valve to lap position without attempting to recharge the auxiliary reservoirs, leaving valve in this position until all brakes in train have fully released, when the brakes should be reapplied and the stop made with a mild application, not exceeding 10 to 12 pounds reduction in total. This, however, should not be construed to mean that where train is approaching terminal points or extensive yards, where ample time is available for recharging brakes between each application, in which case the brakes should be fully recharged before their reapplication.

Before coming to a full stop the brakes should be released to obviate the recoil of trucks incident in holding brakes on until the train is stopped.

In the way of comments on the practice of using two applications instead of one in making service stops with passenger trains, a great deal of argument has been heard in favor of the one-application principle, for the reason that less time and distance is required in which to make the stop. This argument would doubtless prove to be correct if it were possible for engineers to make all stops by applying the brakes full force and at precisely the right place at the beginning, in order to make the final stop at the proper place; but as this is an impossibility, it remains that to avoid having the brakes applied full force or nearly so just before stopping, that a quicker stop can be made with two than with one application, if the brakes are set at nearly full force at first, and when released and reapplied to graduate

brake force to suit the conditions, and by this means overcome the momentum of train at its greatest speed with a proportionately strong brake force.

USING SAND FOR STATION STOPS.

When conditions of track require the use of sand in making station stops, care must be exercised that sand is used continuously throughout the entire stop, or at least, that sand is running before any danger of wheels sliding occurs and sand then used until train is stopped.

"KICKING OFF" BRAKES.

The practice of "kicking off" brakes on a portion of train should be discouraged even in passenger service, inasmuch that if brakes are again applied, the brakes not so released will of necessity have a tendency to skid wheels as well as to stick in the final releasing, not to mention the surging of cars in train of any considerable length, tending to cause breaks-in-two and other annoyances.

MAKING SERVICE STOPS—FREIGHT TRAINS.

When stopping freight trains at way stations and other service stops, owing to the moderate speeds at which these trains are usually run, one application, rather than two, is recommended, because more care and skill must be exercised in releasing brakes on long freight trains at slow speeds, to avoid parting and undue strain to draw-gear. An economy of air is also realized, which is more important with freight than is the case in passenger service.

The brakes should always be held on until after the train comes to a full stop, as unlike passenger cars, the brakes are so hung as to cause no reaction to car body when car comes to rest with brakes set, and unless the locomotive is equipped with some method of brake-retaining device, the tendency is to cause severe strains to draw gear and consequent breaks-in-two.

When stopping at water cranes or other accurate stops, it is generally productive of better results to cut engine from train, after having stopped train before arriving at the objective point.

The time consumed in uncoupling and again coupling up engine to train will often be time well expended, in saving draw gear, breakages, etc.

When releasing brakes, the length of time at which brake valve should be held in release before returning to running position, cannot be specified to cover all cases, as it is dependent upon the amount of excess pressure, size of main reservoir, length of train and the amount of air drawn off in making the application; hence, this must be left wholly to the engineer's judgment, who must bear in mind that the pressure must have time to pass back to rear end of train pipe in sufficient volume to insure the prompt release of all brakes; and that no possible harm can come from leaving the F-6 brake valve in full release until nearly maximum train pipe pressure has been restored, but must not be left in release long enough to overcharge auxiliary reservoirs,—the effect of which is noted elsewhere in this paper.

LIGHT VS. HEAVY REDUCTIONS.

The effect of light versus heavy reductions on the final releasing of brakes is also of paramount importance in handling long trains, as where but 5 to 7 lbs. are drawn off it is naturally more difficult to release brakes than when 12 to 15 lbs. reduction is made, due to the lesser auxiliary reservoir pressure after the greater reduction; but this must not be confounded with the practice of some engineers making further reductions after brakes sticking are already applied at full force, as frequently occurs after adding cars to train and greatly reducing train line and main reservoir pressures, which practice is by no means commendable.

CAUSE OF BRAKES STICKING.

The most natural cause for brakes to "stick" is insufficient or no excess pressure; main reservoir too small or water in same, and brake valve returned to release position too soon—before pressure is transmitted in force to rear end of train.

The effect of sticking brakes is to cause more flat wheels than from all other causes combined, and with a view to reduce the number of flat wheels on railways, your committee suggest that trainmen be held jointly responsible with the engineer; in this connection the trainmen's duties should be to look the train over at all stops to see that brakes are fully released; this, however, applies more especially to freight trains, which for various reasons give more cause for brakes to stick.

The practice of "kicking off" brakes on freight trains, when brakes are holding too strong, cannot be too strongly condemned; the results are certainly serious in the way of slid flat wheels, cracked and broken wheels on grades and by no means the least in the pulling out of draw bars, etc.

HOLDING TRAINS ON DESCENDING GRADE.

When holding trains on descending grades, too much attention is frequently given to the economy of air pressure. This is in itself a vital point, and is one that must not be lost to view; but it is sometimes carried to extremes whereby other items are left to suffer. If all brakes were in perfect order and free from leakages this would be the main point at issue, but unfortunately, we do not always find the brakes in the ideal condition sought for; hence, to not overtax the wheels under some cars and leave others to run practically unbraked, the engineer should so control his braking as to release as often as the capacity of air pump will, when running at fair speed, maintain maximum pressure.

When recharging on grades, the brake valve should always be in full release until brakes are well recharged to maximum pressure, as the practice of recharging with brake valve in running position, even on light grades, is the means of sticking brakes, causing overheated and cracked wheels.

The driver and truck brakes should always be used on grades, as elsewhere, except when the water brake is used, and for other special reasons provided by the rules governing same

### DOUBLE HEADERS.

When two or more engines are used on one train and the forward engineer is using the brakes, as should be the case, the rear engineer must cut the brake valve out by closing cutout cock in train line under brake valve provided for this purpose. The practice of lapping valve on second engine has frequently been the cause of serious results, and the practice cannot be too strongly condemned. If it is desirable to use air from more than one engine, the better practice is to pipe the engines so that all the main reservoirs can be united and the leading man have use of all storage space and air compressor capacity; the cost of piping will be trifling, and will be compensated for by the saving in wear and tear, as when one pump is greatly overtaxed.

The practice of the second man cutting in at the proper time to recharge and again closing cutout cock before brakes are reapplied, has given very fair results, but it is open to criticism, owing to the possibilities of mistakes that are likely to occur.

### HAND BRAKES VS. AIR BRAKES ON GRADES.

When trains are fully equipped with air brakes and these are in such condition as to hold train with perfect safety, no hand brakes should be used; for the reason that where hand and air brakes are both used on the same car, too much brake force is usually developed and wheels largely overheated on a few cars. The greatest known safety in holding trains on mountain grades is low speed and the brake on each car performing its share of holding power. However, in isolated cases the condition of brakes, grade, etc., is such as to make the use of hand brakes in conjunction with air a necessity; in this case every available hand brake in the train should be used in such manner as to give the most uniform distribution of brake power possible, but with due consideration for the tendency of wheels sliding under light loads and empty cars.

The pressure retaining value should also be used most liberally, even on light grades, as it adds greatly to the capacity of air pump. As a pretext for not using the retainers, the trainmen will at times advance the theory that nothing beneficial develops from their use, owing to the fact that in some instances the brakes will be found fully released in five or ten minutes after brakes have been released from the engine, not realizing the great advantage obtained from the piston being held from returning to release position, even though no appreciable air be held in the cylinder.

It is true that too many roads neglect the pressure retaining valve because the nature of the road by whom these cars are owned is such as not to require its use. The committee would therefore emphasize the importance of all cars having the retainers and pipes to same being given the same care as any other part of the brake mechanism.

### TRAIN PARTING ON GRADE.

When a train becomes parted, or hose fractured, whereby all air exhausts from the train line on either ascending or descending grade, the

angle cocks should be closed immediately in front and rear of fracture and hand brakes used at once to hold train in event that air brakes release through leakage.

### THE LE CHATELIER, OR WATER BRAKE.

The Le Chatelier brake, commonly known as the water brake, is recommended for general use on mountain grades as an adjunct in braking, owing to its efficiency, and it is inexpensive; it has been developed that this device will hold from sixty to ninety per cent. of the tonnage the engine is capable of hauling up the same grade, according to speed condition of cylinder packing, etc. It is easy of graduation but should always be used continuously over the entire length of grade and not intermittently, in which case an increased amount of lubrication must be used in valves and in cylinders, as in each case when the Le Chatelier is cut off, the valves and cylinder packing are found to be dry and requires lubrication in the same degree as if the engine had been working "wet steam." While on the other hand, so long as steam produced from water taken from boiler is working through cylinders, this in itself is a lubricant, and consequently a safeguard against dry surfaces.

### OVERCHARGING BRAKES.

It has been noticed that in some cases engineers in their anxiety to keep brakes from "leaking on," adopt the practice of throwing the brake valve handle to release position intermittently, as well as leaving it in this position too long when releasing brakes after an application, and in either case overcharging the brakes, that is, charging the brakes to a greater pressure than that at which the feed valve in the F-6 or the air pump governor with the D-8 valves is adjusted to carry in the train line, and by this method cause brakes to "leak on," inasmuch as when the brake valve is returned to running or feed position, no air can pass into train line until this pressure is reduced to that at which the feed valve or governor is adjusted to carry.

Hence the engineer should be instructed to leave the brake valve in release position just long enough to start all brakes to release with a certainty and return to running position before brakes are overcharged, and when this is done and brakes are all released, not to disturb the valve from this position until brakes are again applied and it is desired to release fully. Also keep "warning port" well open in brake valve.

Another element which is the source of much trouble, causing brakes to "leak on" is that of air brake "parasites," such as bell ringers, pneumatic sanders, etc. This trouble, however, is almost exclusively confined to where brake valves are used, other than the F-6 type, or with all valves having the train line pressure governed by the air pump governor instead of the feed valve, and while sensitive acting air pump governors will do much to offset this, any kind of pump governor would avail nothing if air is used more rapidly than produced by air pump, and if the train line leaks to any extent whatever.

### AMOUNT OF EXCESS PRESSURE.

The practice of fixing an arbitrary amount of excess pressure to be carried for all conditions of service is not commendable. It is as reasonable to assume that an old 15 inch by 22 inch cylinder engine will pull the same tonnage as a modern 22 inch by 34 inch mastodon would do, as to expect a fixed 20 pounds of excess, regardless of the size of main reservoir and the amount of water it contains, will produce equal results under all conditions of duty. Hence your committee recommend that the size of main reservoir and the amount of excess pressure carried be made commensurate to the surrounding conditions, or actual requirements.

### DEFECTIVE TRIPLE VALVES.

When a brake is found which enters into quick action under service application, no pains should be spared to locate this at the first opportunity, by the engineer reporting the condition to the trainmen or carmen at the first stop, who should use all endeavors to locate and cut out the brake on this car ( unless repairs can be made at once). If brakes are cut out, owing to this defect, defect cards or other effective means should be employed to insure that the triple valves will receive proper attention at the earliest moment.

### EMERGENCY APPLICATIONS.

When emergency applications are required, the brake valve should always be carried to full emergency position and left there, for the reason that a large per cent. of brakes still in use are plain (non-quick-acting) as also a certain type of triple which is recognized as quick-acting, equalizes at but fifty pounds instead of sixty pounds as does the standard. Hence the brakes equalizing at the twenty per cent less pressure, tends to immediately release, unless the train line pressure is reduced below the lowest point of equalization.

Your Committee also beg to submit the following chapter of "DON'TS" for the engineer's consideration:

## FORTY "DON'TS" TO ENGINEMEN.

1. DON'T start your air pump at full speed until 20 or 30 lbs. of air pressure has accumulated. This will cause broken pistons and otherwise damage air pump.

2. DON'T use two teaspoonsful of oil in the air cylinder of air pump because one may be necessary at each oiling; too much oil will gum pump brake valve, governor, signal reducer and triple valves, as well as bell-ringer and all other attachments. Use the least amount of oil in air cylinder that will keep it properly lubricated.

3. DON'T think because your air pump is well packed, no water will accumulate in your main reservoir; drain main reservoir every few days; the water you find is squeezed out of the air by compression.

4. DON'T run your air pump with wide open steam throttle unless it is necessary; your air pump will produce more air per stroke at a moderate speed, also will keep down pump failures and cost of repairs.

5. DON'T lubricate your brake valve by putting oil in the air-cylinder of the air pump when valve works hard; this practice is usually the disease not the remedy.

6. DON'T use kerosene or other light oil to clean out air cylinder of air pump, especially when pump is hot; when used in this manner it is not distantly related to dynamite.

7. DON'T pour oil into the feed valve attachment to engineer's brake valve when it fails to operate properly; oil will do more harm than good; have the valve dissected and the defect corrected by "the man who knows how."

8. DON'T depend on the brakes being tested from the rear of the train by opening and closing angle cocks as an assurance that you can operate them from the engine; brake failures have resulted from this.

Moral: test your own brakes with your own appliances.

9. DON'T think when a brake in a train "sticks" that this brake is always out of repair; look to your excess pressure and see that there is no water in your main reservoir, depriving you of storage space; also leave your brake valve in full release the proper length of time.

10. DON'T think you can release the brakes on a freight train at four miles per hour with the same degree of safety that you could at four times four; you are more apt to break your train in two when releasing at slow speed.

11. DON'T use independent locomotive brakes to bunch the slack in a long freight train before using the train brakes; better work is done by the brake valve if used properly from the start.

12. DON'T "kick off" brakes on a long train when you are going to stop short; release all of your brakes in time and re-apply again and you will have less draw heads to your credit, as well as sticking brakes and slid flat wheels.

13. DON'T use sand on a slippery rail after you find that you are not going to stop where you wish, unless flat wheels are preferable to running by

Moral: when using sand use it a full train length before any danger of wheels sliding exists, and continue to use sand until train stops; no amount of sand on rail will unlock wheels after they are once sliding.

14. DON'T reverse engine when driver brakes are set, as they are most certain to lock and slide; best results are obtained in maintaining driver brake in first-class condition, when a quicker stop can be made than with a poor brake and engine reversed.

15. DON'T release brakes on a long train when in motion until brake valve has equalized from the last application, as the two opposing currents of air colliding within the train line will be certain to provoke a coalition of forces on the outside and cause a rupture of the draw gear; wait until valve has shut off at train line discharge before releasing the brakes.

16. DON'T open throttle on your engine as soon as you put brake valve to release position when brakes are set, but wait from 6 to 10 seconds time for brakes to fully release before opening throttle valve; it requires time for air to travel from engine to rear end of train and time for air to fully exhaust from brake cylinders.

17. DON'T think you can recharge the brakes on a train as quickly by leaving your brake valve in running position as in full release when an excess of pressure is carried in the main reservoir; when recharging, especially on grade, leave your valve in full release until you know that all brakes are recharged. It will enable you to maintain a more uniform speed on a descending grade, and less danger will exist of running short of air.

18. DON'T get impatient when you think the brakes are not operating to your liking and blame them for defects which may exist only in your imagination. It may be that you are not so skillful in handling the brakes as your neighbor. Think a little when such trouble is upon you, you may find the remedy and learn something more than you already know.

19. DON'T cut out your driver brakes imagining they are causing your driving boxes injury. This reasoning was exploded long ago. Keep up your wedges and you'll have no trouble and you'll have a valuable stopping device which you may sometime need. Don't use your driver brake as an emergency device only; you may sometime in an emergency not have time to put it to work, or may forget it's on your engine; instances of this kind have been known to occur. Cut it in and use it in conjunction with train brakes always. Your train will stop ever so much quicker. It will also probably occur to you that if you do not, the brakes on the cars you are hauling will have to stop your engine.

20. DON'T fail to have the round house people look after the repairs of your pump when required; it's not very frequent but will save money for the company you work for.

21. DON'T imagine you must have 100 pounds of air or more when 70 will produce the greatest brake force the wheels will bear without sliding if the proportions of the brake gear are properly calculated. This you can readily ascertain to your satisfaction, by making use of the simple rules contained in the instruction book. If they are not, call the attention of the proper official to the matter.

22. DON'T imagine that you can stop a long train of cars by operating the brakes on a few of the head ones next the engine in as short distance as if the entire number of cars in the train were fitted with brakes, and because you can't increase your air pressure in an attempt to do so. Half a dozen to ten cars braked will handle a train of 25 to 40 cars quite nicely on ordinary grades if properly used, but they can be made to do so much and no more.

23. DON'T attempt to stop a train in a few feet when you have several hundred in which to do it, and no danger impending.

24. DON'T set up the rear of a train by applying the brakes suddenly at the head end in an ordinary stop. It's so easily done the right way, and pleasanter to the crew in the caboose. Apply the brakes gently until you

have the slack of the train against your engine, and thereafter as hard as you please. Here's a splendid opportunity to show your skill.

25. DON'T have leaky air pipes around your engines or cars. It isn't economical any more than if so much steam were blowing away, and then it's hard on the pump.

26. DON'T use small main reservoirs on your engines. Big ones don't cost much if any more, and they hold a lot more air and the brakes operate better with plenty of it. If you can't find room for the big one you can for the two smaller ones. Don't put the main reservoir on the top of the tank, it isn't good practice and you'll regret it some time in winter weather.

27. DON'T think that your old friend, the three-way cock, is going to survive always just because you are used to its ways and you are just a little bit loathe to try something better in the new brake valve; you'll get used to it shortly and it is really needed as the injector was when it took the place of your pump. Don't you remember what you said about the change? Injectors are a good thing now, aren't they, since you're used to them?

28. DON'T fail to pull the handle of your brake valve to "running position" a reasonable time after you've released your brakes. An excess pressure of 20 to 25 pounds in the main reservoir comes exceedingly handy when you have a long train. It's a good thing with short trains as well.

29. DON'T always blame the trouble on the brake valve, if, because of leaking air pipes, you can't keep the brakes off in "running position." Have the leaks stopped.

30. DON'T "cut out" the brakes on any cars in the train unless there is something wrong with the brake gear. Even then a little thought and judgment may enable you to apply the remedy. Operate them all. There's just a little trick in doing it on a long train, but you can learn it easily if you will only try. Here is where the excess pressure comes particularly handy and helps you out. Besides you can stop quicker.

31. DON'T fail to call the attention of your crew and the inspector to any defect that may exist in the brake gear or apparatus sufficient to make it inoperative, and that you can't remedy. Prompt repairs may be possible and save you some future anxiety.

32. DON'T get excited because the grades are a little steep. Keep cool and your wits about you, a good supply of air in reserve, use it judiciously and don't fritter it away by unnecessary applications and releasing of brakes, and you are perfectly safe on the steepest grades of the ordinary railway.

33. DON'T apply the emergency brake unless it is absolutely necessary. The effect of so doing is especially disagreeable to passengers, when you are creeping up to a water crane or a coal chute, and they talk about you, while your passenger department promised them a smoother ride than via the other route. You can make smoother stops if you try.

34. DON'T exhaust train pipe pressure to zero in applying brakes, it won't do any good, they are on as hard as they can be applied long before this, and you waste the difference in air. If you've been addicted to this prac-

**tice in the past now is a good time to reform. Somebody who knows better will find out your practice and tell it as a good joke on you at the round house or lodge room.**

**35. DON'T fail to take up the slack in the brake gear when necessary. If you don't you can't stop so quickly, and it takes more air when the pistons bottom on the front heads. If your brake gear is weak and contributes to this defect stiffen it up. It pays to do so and wooden brake beams are out of date. Metallic beams are cheaper in the long run, and better.**

**36. DON'T think because a six wheel truck car has an air brake on it, and shoes acting only upon four pairs of wheels, it can be stopped as quickly as a four wheel truck car. It wont, but it can be made to if shoes are applied to all of the truck wheels as they ought to be, and it's safer.**

**37. DON'T fail to clean triple valves and cylinders occasionally, how often depends on what goes into the train pipe. Keep out foreign matter which should not get there and will not if some of these "don'ts" are observed, and you need not clean them for quite a long season. A half gill of good oil will answer the brake cylinder better than a quart. Economize.**

**38. DON'T fail to hang up the brake hose in the "dummy" when you uncouple it. Your road may be sandy and sparks are sometime thrown by the engine, we've found lots of this stuff in the triple valves. It don't do them any good, and it annoys the fellows who have to clean them. It's a good idea to blow out the pipes with steam and ease out the fins at their ends before putting them up, it will save you lots of trouble later on.**

**39. DON'T permit your air pressure to fall below the standard; nor allow speed of train to exceed average maximum when descending heavy grades; it is exceedingly dangerous. Low brake power may control the train at low speed, but is quite certain not to at high speeds.**

**40. DON'T, when running double headers, leave cut-out cock open on second engine and depend on lapping your brake valve; an opening for mistakes is too apparent from this practice.**

**Moral : Use the brake as it is intended and all wi l go well.**

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The President: Gentlemen, you have heard the report read by Mr. Hedendahl, it is now open for discussion. I think the report is a very able one.

D. Meadows (M. C.): As it is after one o'clock, I move that we adjourn.

Seconded by Mr. C. H. Hogan.

Secretary Thompson: In connection with this Air Brake subject I would like to say that there are some four or five air brake cars down at the Union Depot, also one of the new Cor-

respondence School cars, and I think that this afternoon would be a very good time for the members to go and see them. They were brought here for that particular purpose, and there are several very good cars and they will be very interesting to all of the members.

C. B. Conger: The Correspondence School car is not an air brake car, it is a sectional model car. The big air brake car is on its way somewhere between Grand Rapids and Cleveland. I would like to ask if there is more than one car here.

Secretary Thompson: Yes, I understand there are three.

The President: Gentlemen, there is a motion before the house by Mr. Meadows, seconded by Mr. Hogan, that we adjourn until nine o'clock tomorrow morning. Carried.

The President: We will adjourn until nine o'clock tomorrow morning.

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## Second Session.

WEDNESDAY, September 12, 1900.

President Stack called the Convention to order at 9:10 a. m.

The President: Gentlemen, we will now proceed to discuss the second printed report: "The proper manner of handling Air Brake Trains on the Road."

Eugene McAuliffe (International Correspondence School): There are two or three points I made note of yesterday; I noticed the report recommends the tests to be made, whenever possible, by the engineer. I find on a great many roads that the engineer's duty is at the telegraph office, getting orders, and it takes him away from his engine just at that important time; I think it is essential that the man who has the responsibility of the air brake should be on his engine at the time the terminal tests are made; on roads that I have recently gone over I find the engineer at the telegraph office, and the fireman and possibly some other train hand delegated to make the terminal tests.

In going over the various roads I notice a remarkably unfortunate condition of air pumps, I think the cause of a great deal of poor braking is that they have not standard air pressure. I found a man carrying 51 pounds pressure, another carrying 85 pounds.

I noticed also that the train line reduction was excessive in a great many cases even to the extent of 40 to 45 pounds on passenger trains. And just another thing, I have noticed in my six months experience a great many trainmen are loath to take up the air brake question because of the fact that railroad officials do not put pressure enough on the trainmen in the matter of requiring knowledge of the air brake, that is their part of it. Trainmen are indifferent, they are of the opinion that enginemen should acquire this knowledge; I do not believe that one man on a train should have all the knowledge of the manipulation of the air brake, I think every other man should have to know something about it and I believe that it is essential that every man should have at least some knowledge of this apparatus. As to the matter of locating a stuck triple, I think that requires the attention of every man on the train, the engineer on his engine, the trainmen strung along at intervals, possibly using the fireman to take care of the first four or five cars; I am speaking of fast freight trains where four or five minutes time means a great deal. These, I think, are things that deserve some attention.

W. G. Wallace (C. & N. W.): This subject is "The proper manner of handling air brake trains on the road" and I think that the report is very complete, but there are some few points in here that I would like to hear discussed before the convention. Now the difference in handling air brake trains and handling hand brake trains is very slight, to do good work, in my opinon, and in a simple way I have endeavored to get the enginemen to think that the air brake was their friend and to handle the brake and the train just as if the brakeman was a particular friend of theirs and they were trying to make the work as easy as possible for him.

I would say that I served my apprenticeship in the hand brake, about the age of a boy who thinks he is something of a hustler—we have all had that age, we used to let the train run down into the town to a point where they would have to get right

after them; we hauled 18 cars many a time, we would set all the brakes on the 18 cars, and my partner and I would swap yarns in the middle of the train and we had done all we could do, and the chances are that we stopped either on one side or the other of the water tank; then to avoid a long wait the fireman and conductor would have to get out and help let off the brakes.

I had a change in conductors—the first thing he said to me was, "I don't know what kind of work you have been doing, but I will show you how to make a stop" and he begun to set brakes further back. We gradually increased the braking force on the train until we got down pretty near to where we wanted to stop, at that time we had a light application, that is, we would only have four to six brakes set when we formerly had the whole 18; where if we were going to stop too short we would release one or two and if we thought we were going to run by we would set one or two; we got along nicely and we did not have the callouses on the hand which were the trade mark of the old times. Now I think in handling a freight train in that manner that the engineer coming up to the station by making his first application in time, getting hold of his train and using his best judgment, can usually handle the train in the most satisfactory manner.

I note in the Committee Report there is a sentence in regard to the second application on passenger trains. Now when we first started to handle air brakes we did not know as much about air as some of us do today. The gentlemen who came to our road from the Westinghouse Company recommended one application, it has gone from that to two and sometimes three and four and I believe that the time is coming when we will get back to the one application for stops in our passenger train service just the same as all our members went back to the partly closed throttle instead of the wide open throttle at one of our previous conventions.

In speaking of the smooth ride that the passenger department has promised the passenger, a good many of you in riding over the road where they practice the two application will find that your train is running along, making good time and the brake goes on quite hard, some of us brace our feet against the next seat in front until we find out if that man is making or doing his work

with the two application rule. Now right here the report says: "If it were possible for engineers to make all stops by applying the brakes full force and at precisely the right place at the beginning, in order to make final stop at the proper place." Now it would hardly be expected that the brakeman of today could make that reduction and have their brakes fully applied to make the stop at the right place. I do not mean we are handling passenger trains with the one application practice, we begin far enough back, we come up to the station or water tank and make the stop, but they never get their brakes applied with full force because when they do they are through, it is a chance stop any time after you get your brake fully applied if you have made an error in judgment there is nothing further for you to do except to go by. I also find in following that matter up that the man who makes his stop with one application, as a rule has very few slid wheels charged up to him. Now that might not apply on every line, there may be conditions where the two applications would be preferable to one, but I think that the engineer who has the judgment to handle his train carefully, can do better work and make it pleasanter for the passengers with one application than he can with two. I expect to get sat down upon and I will not go into it any further.

The President: Gentlemen, we have with us this morning Mr. P. P. Wright, Assistant General Manager of the Lake Shore, and we would be pleased to hear from him.

Mr. P. P. Wright (L. S. & M. S.): If I was capable of making a speech I hardly think I could say anything that would enlighten this intelligent body of men that is before me. I wish to say that I regard it as a distinguished honor having been invited to be present at your meeting. I am interested in what has been said, and I wish to return my thanks for the invitation, which I consider a high honor, and wish to say to the gentleman that I have nothing that I can offer that would be valuable to them, as they all understand their business a great deal better than I do. I will not be able to remain a great while, but will remain as long as I can; I have engagements which will make it impossible for me to stay as long as I would like to. I thank you again for this honor.

The President: In behalf of the members of this Association I wish to thank you for meeting with us this morning, we would be pleased to have you remain with us as long as you can.

F. B. Farmer (W. A. B. Co.): Mr. Wallace has covered the ground very thoroughly to my mind, but the one application rule I do not think will work, in making water tank stops or where the station platforms are short it becomes necessary as a general rule to make the two applications in making a water tank stop and stations that have short platforms.

H. C. Ettinger (Wabash Ry.): While I have not come prepared to make a talk on the slid flat wheel question or on the one or two application question, if I had I could possibly have furnished some information in regard to that line that might of been of interest. We have had on the road that I represent, considerable trouble with wheels sliding and we have gone into the matter very thoroughly. Inasmuch as the engineer insists that he was not at fault we put on extra inspectors at some points to locate if possible where the damage was done and I am safe in saying that we found that it was most invariably done by men making the stops with one application; my company furnished me with a pressure recorder which I use to a great extent and am firm in the belief that it has assisted largely in locating our trouble which I found was due to men making the stop with one application; we have a railroad that the ballast is of coal slack in some places where our high speed trains have to stop and I have found that the most skilled men in handling the brakes were charged with the most slid wheels; this come under my personal observation; one of the inspectors said, "Mr. Ettinger, I wish you would see what is wrong with this engineer, he is charged with sliding wheels while other men on the same train with the same engine very seldom if ever are charged with flat wheels. I went out with a pressure recorder on that train, it is a train that runs over the road in the worst hour of the day for slid wheels, that is between the hours of one and seven A. M, it was decidedly a bad place to handle a train and I found the man who was repeatedly charged with wheel sliding was by far the most skilled man in handling the brake; as a matter of fact the other two men could not make the stop with one application, but this man who was repeatedly charged with

slid wheels, I never saw a more skilled man in handling brakes. If I remember right he made 51 stops with an average of eleven pounds of air per stop; he did not only do that one day but every day; he got the brakes off so there was no re-coil of trucks; but still, the superintendent said, he must change his practice of braking or we will have to put him on freight; now to get that man to change his practice of braking we had to do just what a lot of men will have to do to learn the two applications; he has to learn braking all over again. I do not care how proficient a man is in making one application, when you insist on his making the stop with two applications, he has to learn all over again and after I had explained to the engineer what was wanted and insisted on its being done I will say that the trouble of sliding wheels largely decreased on the train that that man was pulling. Another case came under my observation where one hundred wheels had been slid by one engineer in the course of three months and as there was no one else pulling that train he could not shift the responsibility on the "other fellow". He was about to be taken out of passenger service, he was a very successful manipulator of the brakes and he said to me; I do not know what I am going to do, I make these stops with one application, use just as little air as I can and I begin way back and use sand, in fact I run out of sand making my stops. I said to him, just let your sand lever alone and depend on the two applications; if you have got a stop where you are satisfied that the wheels will pick up after making the two applications, make three of them; air is cheap, but it costs this company a lot of money replacing these wheels. I can say that my record shows that that man has been charged with only two or three flat wheels since that time, and that is two or three months ago. Other cases have come to my notice of that kind, and I find it is the man who is using lots of sand and the man who is making stops with one application is the fellow who is sliding the wheels, I object to the use of sand, I notice the report tolerates that, but we have got a man on one of the worst divisions we have that has been pulling the fast local passenger train through Missouri where they have this black muck, and I will say to you that that man has not a slid flat wheel charged to him in fifteen months; that man never uses a grain of sand. Men who

have had so much trouble with slid wheels were found to be useing sand. Now we say, begin further back, get the sand under the train and use a little air; that is the practice in a good many places; I have gone out on the road and stepped back when the train came in where I could see the movement of every wheel on the train; a man would come in with the sand running on both sides making one of these drop stops; he is all in when he gets pretty close to the platform and he dare not let go for fear he will go by; the engine, mail car, express car, and possibly the smoker goes over the muddy crossing all right, but by the time the chair car, sleepers and dining car come along, the sand is so mixed up with the mud that when those wheels come along, they pick up and they only have to slide a very few feet to have a very big flat spot on them, that is the disadvantage of using sand where you have this mud to contend with. Now, we find that there is a fast local run, you have to stop your train at the speed of 60 miles in 45 to 50 seconds, then the question arises how are you going to do that without sliding your wheels? The only way out of it is to make two applications; Mr. Wallace says, that results in a rough stop; I will admit that occasionally the engineer will make a heavy reduction, he does it by making a 15 to 20 pound reduction, but the two application man who understands the conditions, and has it down fine, I think he can make just as smooth a stop as he can with one; furthermore, the man who makes the one application stop usually has the trucks badly tipped, and it takes the skillful operators to get the brakes off in time to let them right themselves before the train stops. If you do hard braking at high speed, release, then make your final stop with a light application, that will avoid a great deal of back lunge of the car.

W. G. Wallace (C. & N. W.): I am a little bit at a loss to know just what the conditions are on the line of road the last speaker has spoken of, but I consider that I am fortunate in not having to handle the air brake trains on his line as I would not know how to handle the trains under those conditions. I have had a short experience with a pressure recording gauge and the engineers that I have in mind, had practiced stopping with one application and were making their stops with 12 to 13 pounds

reduction in train line for their average stop; now according to his statement, he says that the man who had been sliding the most wheels was the man who had made his stops with one application and 11 pounds reduction. I think you have that engineer in rather a bad box; if that is the case he certainly must be a skilled man to prevent sliding wheels and stop his train where he desires, and if he should make a full reduction of 15 to 20 pounds on his first application and then make his second application the chances are that he will be sliding wheels again. I have not the figures just what pressure that would be in the brake cylinder—11 pounds pressure—he would get that on the two applications if he practiced that method; it only requires one bad stop to slide wheels. A man comes into a place and he overlooks his mark, he does not make the stop on 11 pounds, but he has to go after them, he is all in, he has the full application and he has the wheels sliding. Now it would not be any use to insist on one application or two applications, if you say two applications you have got to follow it up and insist on two applications being used; another way of getting results I find is to put the pressure recorder on and let the man do his own running, so the moment he laps that valve it will put it on the sheets and it will show every time he lets go of the brake. If he makes one bad stop on one application, go after him, and if you do that you will find out that you will get good results—we have some of the finest regulated trains in our part of the country and the hardest conditions to contend with, but when you tolerate making one application stop here, two applications there and one application at the next station, I am firm in the belief that your trouble of slid wheels will still continue.

J. S. Bauder (L. S. & M. S.): Referring to the last speaker's remarks I would like to ask a few questions. In making stops I believe that the sand is more to blame for the flat spots on his wheels than with one or two applications. On the road that I represent we have some very heavy trains, 90 per cent. of our stops are made with one application; we have an engineer who has run one of our local trains a long time, and he invariably makes every station stop with one application, and I do not know as he has ever had a flat wheel charged to him, and flat wheels on passenger trains on the Lake Shore road are very few and far between, and

we have always encouraged the men to make their stops with one application.

William Owens (N. Y. A. B. Co.): The trouble that I find in using sand while making your one application is, you see you are going by and will then go to pulling your sand lever wide open; if you are going to use sand commence using the sand about the time you apply the brakes. In regard to the two applications, I find it is a hard matter to get a great many engineers to bring the handle back to lap and they leave their handle at full release too long. That is the one fault that I found in a great many cases.

Mr. Ettinger (Wabash, R. R.): The gentleman says they do not know what a slid wheel is on the Lake Shore. Possibly not, but we do. I'll be honest, and I confess we still have them some, but our slid flat wheels have been reduced 75 per cent. One of our neighboring Superintendents advised one of our Superintendents that they were not having a great many slid flat wheels; after making a thorough investigation we found that while we had more stops that we run 29,003 miles to one slid flat wheel, on that same road where they had scarcely any slid flat wheels, they run only 9,000 miles; investigation further proved that on our road the car department was after their inspectors so hard that they would find a slid flat piece as big as a dime; they did not notice so small a place on the other road. It depends largely on what you charge the engineer with; he comes in with a spot an inch long on a wheel and he is charged with it and of course he has a hard game to go against; much harder than the man who has nothing to be charged with unless the wheel is so bad it has to be taken off.

Otto Best (N. C. & St. L. R. R.): I would like to agree with Mr. Ettinger in what he says about the handling of passenger trains with two applications. It is well known that with trains at a high rate of speed we have less brake shoe friction and as the speed decreases the friction increases. Let us look at the high speed brake used on the New York Central the past five or six years and where there are no slid flat wheels to be charged to the brake; it works exactly upon the same principle as the two applications we are trying to use today on our passenger trains. As

the speed decreases the pressure decreases. Take an engineer handling a passenger train at 60 miles an hour, he makes a reduction of 9 to 10 pounds, gets the pressure on the wheels and good friction and high rate of speed; after he has his train under control, releases brake, brings the brake valve handle back to lap and then makes his final stop, whereas, leaving the brake applied with his high brake cylinder pressure at a low rate of speed, it means slid wheels. About two years ago we were braking our passenger equipment at 80 and 75 per cent; we had considerable trouble with slid wheels. We raised our braking power up to 92 per cent on our passenger trains and used two applications to stop, as nearly as possible as we can get the engineers to do so, which you will agree with me is very hard to get them to change after they have been in the old rut, and though we have very few slid flat wheels I am not going to say that we do not have slid flat wheels on passenger trains; occasionally we do. I attribute the success of doing away with most of the flat wheels on passenger trains to the raising of the braking power to 92 per cent and two applications. In regard to handling of heavy freight trains on mountain grades, we have one mountain eight miles long, 175 feet to the mile where we have been handling coal cars. It has come under my observation lately that in handling trains on a grade as heavy as that to make a heavy reduction immediately upon turning over the hill, not wait until the speed gets up to 15 to 18 miles an hour and then try to check them down as we call it, but apply the brakes soon enough to check your train with a light reduction. After your brakes have taken hold and your train is running about 8 to 10 miles an hour release them, leave the handle in full release long enough to get your train line and auxiliary reservoirs fully recharged while the retainer is doing the work; after that about four pound reduction on top of your retainer pressure in your brake cylinder stops your train nicely. I have found that practice better than trying to run two to four miles on one application. That will not do. Recharge as often as possible and you will have good brake cylinder pressure, good auxiliary reservoir and good train pipe pressure and have your train under control.

C. P. Cass (Westinghouse A. B. Co.): Mr. President: I rather approve of the two application method of handling passen-

ger trains in making station stops, particularly where the rail is bad or the schedule fast. The matter of slid flat wheels in passenger service is partly due to local conditions, and instruction should be given to cover those local conditions. It is not unusual to find a large system where, upon one portion of it, it is very necessary to use two applications in making ordinary station stops to avoid wheels sliding, while upon another portion of the same line where the rail conditions are more favorable and time slower, the one application can be used with good results. In reference to the handling of heavy trains down long and steep grades, I wish to say, I entirely agree with Mr. Best. In the safe operaof such trains down heavy grades, it is best to make a heavy initial reduction immediately after tipping over the summit. This insures catching all brakes that operate. When the train has slowed down sufficiently, release and give the retaining valves a chance to operate. The old practice of attempting to go long distances between releases, in mountain work, was, I think, largely brought about by poor condition of brakes and pumps and small main reservoirs. After the brakes were once applied and released it required so long a time to regain their pressure. The safe operation of heavy trains on heavy grades requires brake equipment maintained in good condition, and train line and auxiliary pressures held as near the maximum as possible by frequent releases and recharging. I should like to emphasize that portion of the report wherein they say: "In mountain work always recharge in full release position, at least till maximum train line pressure has been attained." I found on some of the grades in the West, that when the engineers had a so-called "hard train to hold" they were in the habit of releasing in running position, and were unintentionally sticking brakes on themselves, the result being broken and slid flat wheels, due to that practice. They succeeded in breaking up the practice and the trouble disappeared. The proper method of releasing of brakes on long freight trains is another point engineers should be thoroughly instructed in. For instance, with the older type of engineer's valve with excess valve, they had been accustomed to going to release position, and returning to running position in order to maintain their excess pressure. The force of habit is shown by their handling the F-6 engineer's valve in the

same manner unless they have been instructed differently. They should bear in mind it is necessary for the air to reach the rear car in sufficient volume and pressure to promptly release brakes or stuck brakes will result. The length of time the brake valve is to be left in full release is largely a matter of judgment on the part of the engineman, depending of course on the length of the train, size of main reservoir, amount of air drawn off, etc. Improper manipulation of the engineers valve is, I think, responsible for a good many stuck brakes on long trains.

William Owen (N. Y. A. B. Co.): I have had a little experience with the high speed brake, and I do not think there is much more danger of sliding wheels in service than with the low speed, as air feeds out of the brake cylinders through the automatic valves nearly as fast as it feeds in from the auxiliaries. In regard to releasing brakes on freight trains at slow speed, say 8 or 10 miles per hour, I would like to ask how it can be done successfully without going to running position, which a great many object to doing.

Otto Best (N. C. & St. L.): I would like to ask if this handling of trains on the mountain, freight trains of 80 to 90 cars going 8 to 10 miles an hour are on local? I would release with a high main reservoir pressure.

C. H. Hogan (N. Y. C. & H. R. R.): I do think that Mr. Best has touched the key note in regard to handling trains properly. I know from my experience in hauling fast trains that I got much better results by making two applications than I got with one. I could do safer braking and I could stop just where I wanted to, while with one application, running at 60 miles an hour, I was very seldom able to stop just where I wanted to. In regard to releasing the brakes on freight trains at a slow rate of speed I think that it is necessary to stop the train before releasing the brakes. I am speaking now of a 70 to 80 car train; unless you do you are liable nine times out of ten to break the train in two. In regard to releasing the air by putting the engineer's valve into running position, I find that we have not had good success by such practice. I get it from men who are thoroughly familiar with the working of the air; they come in every day and tell me they have dropped that practice; they found they were

getting in trouble, where they were handling 30 to 40 cars of air. Take it on fast freights, 35 to 40 cars, the men release the brakes while running, and do it successfully, but on 60, 70 and 80 cars they can not do it. I think that men who have had experience in running real fast passenger trains will bear me out in saying it is necessary in doing real nice braking to make two applications. I notice the report here speaks of cutting out driver brakes. I do not believe the driver brakes should be arranged so that they could be cut out anywhere only at the tripple; because men will forget to cut them in when they want them. I think that is bad practice.

Theo. A. Hedendahl (W. A. B. Co.): In regard to "cut outs" I do not presume there is any railroad east of the Rocky Mountains where that is necessary. The committee had in mind circumstances such as 200-foot grades per mile where consistent driver brake application was overlooked. Under these conditions the driver brake would of necessity have to be cut out. That was what the committee had in mind. In regard to the use of sand, Mr. Ettinger commented somewhat on it; I wish to say that the committee do not urge the use of sand at any time, feeling that it is better. Less sliding of wheels is done by omitting the use of sand if it is possible, but there are conditions of rail, capacity of train, time importance, etc., that requires the use of sand, in which case it is recommended that the sand should be used prior to any danger of wheel sliding, and then continued to be used until the train come to rest.

John McKenzie (Supt. Motive Power, Nickel Plate): I did not intend to say anything on this subject, but I am interested in this air-brake question. The first point that struck me was the two applications. We have had a great deal of trouble to keep down to two applications. We sometimes get four and five and I am glad to see this taken up, and would be glad if we could get it down to two; but the two applications to me brings up the question: "What does it mean?" Does it mean the same application at two different times as to the amount of pressure released or applied as in one case? You say you release 10 pounds—do you do that twice before you make your stop; do you want to have two applications at 10 pounds each time or one application of 10

pounds to make your stop? Suppose a man makes two applications, he finds it is insufficient and he wants to put on the emergency, what is the effect of the emergency in the case after making his one application? That might be interesting. I do not know just what it would do, but I am very glad indeed to hear this question of two applications. I do not believe we practice it on our road at all. I do not believe we recommend it in the car. Our recommendation has always been to use as little air as possible, always knowing that it costs money to pump the air, and if there is more than one application that it was a waste of air and that it means dollars and cents. I have not been able to hear all that has been said, but I want to hear the question brought out very fully.

The President: In behalf of the members I wish to thank you for meeting with us. We will call upon Mr. Farmer to answer your question.

F. B. Farmer (W. A. B. Co.): Mr. Best explained the practice with the high speed brake and that covers pretty well the principle of the two applications. With the same shoe pressure the resultant friction, which is the actual holding power, increases as speed decreases. Therefore, the least chance of wheel sliding is where you need, and can, with safety, do the heaviest braking, as measured by the train pipe reduction. While it does not follow that the heavy initial reduction recommended at high speed should not be broken up into two lighter ones made close together, yet with passenger trains, the ones under consideration, there will be no shock following a heavy service reduction where speed is high. Even the use of emergency will cause no shock, though the sensation of a rather rapid retardation may be experienced, but which is not a shock.

With the two application method, the first application should be made so as to rapidly reduce the speed to, say, fifteen or eighteen miles per hour a moderate distance from the stopping point, at which speed the valve handle should be placed in full release just long enough to operate every triple valve and then returned to lap until the final application, which should be light, is desired. To insure a prompt response of all brakes in the second application it is well tq, immediately on returning to lap, make repeated and

quick movements to service and back to lap until a slight train pipe discharge follows. This will either stop the release of brakes or, by having reached the equalizing point of train pipe, auxiliary and equalizing reservoir pressures, insure a prompt action with the next reduction.

The effect of the two application method on the ability to get desired quick action operation of the triples is in its favor as compared with the single application method, but it is doubted whether the distance required in which to make a quicker stop than at first contemplated would be materially greater with one than the other, there being so many variables.

Concerning the releasing of brakes on long trains and the difficulty experienced from breaking in two, with the introduction of the present standard engineer's valve came a radical change that for some time, at least, was not correctly understood. With the plate D 8 and all previous valves the pump governor was cut out the moment an application was commenced and there was no limit to the main reservoir pressure accumulated except time and steam pressure. As a result, a high main reservoir pressure was almost invariably assured for releasing. At the same time, the lesser average number of air brakes per train than now necessitated commencing the application earlier and applying heavier. It always being true that, up to a full service reduction, or about twenty pounds from seventy pounds, the heavier the application in service the more readily are brakes released, it follows that the conditions of the past were most favorable for a prompt release of all brakes. Another feature that tended to prevent breaking in two at the release was the number of non-air cars at the rear.

The high boiler pressure of modern locomotives renders it necessary, for safety, that main reservoir pressure be governed on all positions of the engineer's valve. This provision of the standard valve was quite generally misunderstood, the limit of main reservoir pressure being commonly placed at ninety pounds, irrespective of size of main reservoir and number of air brake cars to be handled. While train pipe pressure should invariably be regulated at a given amount, the maximum main reservoir possible should be varied to suit the average train to be handled. Where, with long trains, there is an objection to the higher pressure the

pump will have almost constantly to work against, the solution is the duplex governor as used on the M. St. P. & S. Ste. M. Ry. freight engines.

As regards safety on grades, the subject has been so fully covered by Messrs. Best and Cass, whose ideas I endorse, that I have little to add. When a train breaks in two on a grade the part detatched is ordinarily most to be feared and no time should be lost in applying plenty of hand brakes to this portion. If the engine can hold the cars with it the air brakes on this portion should be recharged as soon as the angle cock is closed at the point of separation.

Where a stop exceeding ten minutes is made on a grade it should be the rule to apply the hand brakes and release the air. This assures that the train will not start from air brakes leaking off. Particularly with a descending train, the hand brakes should not be released until the train is fully recharged.

The committee has drawn attention to the danger attending the improper use of the engineer's valve cut out cock with double headers. On level grades it is not uncommon for the second man to keep his valve cut in until he believes an application is about to be made, the object being to assist in keeping pumped up as well as to aid in recharging. In spite of the material aid this renders the pump on the leading engine, the practice should be strongly condemned as it has led to serious accidents. In my opinion it would be better to, in addition to using the cut-out cock, place the engineer's valve on lap, as this would guard against the dangers of both a leaky cut-out cock and forgetting to close the latter.

William Owen (N. Y. A. B. Co.): I fully agree with Mr. Farmer in regard to high excess pressure in handling long freight trains, as I find there is not much danger in breaking in two by releasing at slow speed. I also think it would be a great advantage to put a retaining valve on the driver brakes, with the weight taken out, especially on simple engines. In taking the weight out there would be no danger of heating tires, in case the engineer neglected to turn down the retaining valve handle at the proper time after releasing the brake. I think the driver brake would be slow enough in releasing to hold the train bunched while all car brakes were releasing in ordinary practice, as you all know the air es-

capes through a very small hole when the retainer handle is turned up. I would like to hear from Mr. Schragg of the M. K. & T. in regard to a device which he has for holding the engine brake set while the train brakes are being released.

C. F. Schraag (M. K. & T.): The device Mr. Owens speaks of is simply what we might call a cut-out or three-way cock in branch pipe to driving brake triple. This branch pipe is connected to train line just below brake valve, and the three-way cock placed where the engineer can easily reach it. Engineers turn the handle of this valve at right angles to branch pipe, lapping it before releasing brakes while train is in motion. This keeps driving brakes set while train brakes are released, keeping the slack of train bunched. Should they wish to apply the driving brakes harder they pull the handle further back until air escapes from branch pipe. This valve enables the enginer to release the train brakes, if he finds he is stopping too soon, and still keeps slack of train together by keeping driving brake set, and can stop his train at any point without danger of rough handling.

In regard to cutting off engines of freight trains at water tanks and coal chutes, our engineers would think it a reflection on their skill and knowledge in handling air brake trains should such an order be issued. If they were obliged to have their engines cut off at these places. The same rule would apply for almost every other stop. Our local and some of our through freight trains have to stop way cars alongside of very short platforms and very often opposite freight house doors. As these cars are nearly always near the rear end of the train it is more difficult to stop them at the proper place than an engine at a water tank. Our engineers will stop that car at the door or platform, seldom having to move ahead or back. While we have few trains of eighty cars we often have as high as sixty on local freights.

In regard to the committee's report where they say, in testing, the test should be made by the engineer if possible: I think it should be made by the engineer at all times. Our engineers are instructed to note the length of time it takes the exhaust to close after they have made a reduction, and judge by it the length of his train line. Then if a train man tells him he has a certain number of air cars cut in he will know whether he is correct. An-

other reason is, if at any time on the road an angle cock should be closed accidentally or maliciously, and part of his train line cut out, he will be able to detect it by the exhaust when applying brakes in time to use other means to stop should he not have air brakes enough.

In making stops with passenger trains I agree with the committee in recommending two applications instead of one. If that is wrong then the principle of the high speed brake is wrong. We were obliged to use two applications to prevent having flat wheels. There may be some roads that have no trouble in making stops with one application. Out west it is different, and we are obliged to use two, for the reason that it is impossible to make stops with one application without having a great number of slid wheels. In regard to using sand (while in a great many cases it is not necessary, we find many others where it is), I have tried stopping without it in drizzling weather on down grade, thirty feet to the mile; train would keep on going; there was no stop to it until sand was used. Some parts of our road are worse than others. There, a fine, black, gumbo dust settles on the rail and when it is wet with dew you might as well try to stop your train on a rail greased with soft soap without sand as to try it under these conditions. Now, I believe that when Mr. Ettinger adopted the two application principle, had he allowed the use of sand, I think he would not have any trouble. Allow engineers to use sand on bad rails; ours drop sand before making an application and keep it running until they stop.

Now one of the good features of the two application principle is this: Coming into a station where there are muddy street crossings (any one of them may cause sliding of wheels), we check the speed of our train before coming to this crossing, we release our brakes, then lap our brake valve, and when we are over the crossing we apply them, but with lower pressure. As our train is moving slower we do not need as much pressure as when making the first application. Had our brakes not been released before reaching the crossing the wheels would have begun sliding, and unless they afterward got to turning, flat wheels would be the result. It may also be said in favor of using sand in making stops that we are liable at any time to find sand that has been dropped

by some engineer while pulling out of a station. This sand will be found where train is moving slowly and wheels will be much more likely to be slid by it if sand has not been used by the engineer before reaching this sand than if it has.

Some one spoke about the full and partially closed throttle, and as we have passed from the partially closed to the full open throttle we would also go back to the one application in braking again. I think this is looking at it in the wrong light. The wide open throttle fever was at its height a few years ago, but we have gotten back to the old plan of using just as much as is necessary and no more. I think the same will apply to air brakes. The first braking was done with three or four applications; then one application followed and now we are going back between the two extremes and adapt our braking to the conditions we find existing.

RUNNING TESTS.

The committee's report on running tests recommends where this test is made, that the rear brakeman should be located on the rear air brake car to give the engineer a signal when he notes the brake on this car taking effect.

Now I have never believed it proper (where possible to avoid it), to have an engineer depend on any one else in doing his work. Instructions to make running tests are issued, not so much to enable an engineer to tell whether the rear brake has applied as to tell him how the brakes are holding. Some trains with the same number of brakes can be stopped much sooner than others. Our engineers have been instructed, when making these tests, to note how the brakes take hold so that when they approach a place where a stop is to be made they will know how to handle their train. If their brakes hold well they can run nearer to a stopping place before making an application than they would if their brakes held poorly. They are also instructed to note the length of time it takes for the exhaust from discharge valve to close after they have placed valve on lap, and to tell by that whether they have the same length of train line they had when making standing test. By doing this there is no need of anyone watching for a signal from the rear car. Our objection to depending on train men is this: It is almost impossible to get them out at the proper time, and if an engineer is depending on them and they do not show

themselves he is in a quandary. The transportation department on our road have, at different times, issued bulletins that caused engineers to rely upon train crew, always with disastrous results. For this reason I think engineers should depend upon themselves in making these tests and judge of the length of the train line by the length of time it takes for the exhaust from the discharge valve to close after valve has been placed on lap, and judge the holding power of his brakes by the manner in which they check the speed of the train while test is being made.

Chas. A. Crane (A. T. & S. F.): I do not know as I can say anything of interest to you on this subject. We do handle long freight trains and we try to handle them right, but do not always do it. Mr. Cass came over to our line with a recording gauge, and we got a good deal of information from it. I will mention a particular case, if Mr. Cass will recollect; he and I were going along the road and we came to where there was a fifty-car freight train on the siding, all air. We concluded we would take a ride with them. We connected up the recording gauge, the engineer and fireman and one brakeman were acquainted of our being on the train. The first stop happened to be a water tank stop; when we made that stop Mr. Cass and I sat looking at the gauge. The stop was made, if I remember right, with eleven pounds reduction and one application; we stopped just right at the water tank. I felt very much elated to think that the recording gauge showed up such good practice, but before Mr. Cass got done with that freight train, why, we had to acknowledge that we were very deficient in a great many of our practices. We find with a long train that we have to have a hard and fast rule prohibiting our men releasing the air at a slow rate of speed. We also find that we get better results by stopping and cutting off the engine before reaching coal sheds and water tanks. The point about one application on passenger trains, Mr. Ettinger stated in his remarks that his best brakemen, men that were doing the most skillful work making smooth stops and doing it with one application, I find that that has been my experience with our men. With our heavy passenger trains and heavy engines our men who have the reputation of being smooth handlers, are the men who are making the stops with one application, and we have very little

complaint of slid flat wheels. There was a point in Mr. Ettinger's remarks that I would like to have a little information on; that was his manner of keeping a record charging up the slid wheels to engineers. He stated in his remarks that he had a case of one hundred wheels that had been charged up to one engineer. I think it would be pretty hard to do that on our road as our trains run from Chicago to the Coast. Mr. McAuliffe, in his remarks, brought out a very good point, and that was the education of all in regard to the handling of the brake. We all have a great deal to learn, and I think his point is well taken and I believe that engineers, firemen, brakemen, conductor and all parties concerned should be educated up to the proper manipulation of the brake.

S. D. Hutchins (W. A. B. Co.): Anything that I might say would be but reiterating what has been said, but I notice in the talk this morning that the information brought out here was in favor of saddling the slid flat wheels all on the engineer. Now I do not understand all that. I think that if more attention was paid to the adjustment of the brakes, the proper distribution of braking power and the proper adjustment of piston travel we could reduce slid flat wheels to a minimum. Where you have a five or six car train and three of the cars with the piston travel short, two or three of them long, I do not see how the engineer is going to make a heavy application to stop his train when the braking is done by three of the cars in the train which would invariably result in these three cars getting a heavy enough application to slide the wheels. I think if more attention was paid to the equipment and less tendency to blame the engineer with all the slid wheels, probably that would be work in the right direction. No question but that some engineers make a full application every time they make it; but I think they form a very small percentage. I ran a passenger engine awhile and I cannot recall any time that I had slid wheels. If the braking power is evenly distributed on long trains a stop can be made successfully, and time made by stopping with one application and not use over ten to twelve pounds reduction, which is not going to slide wheels, but if two or three cars must do all the braking the result is that the cars doing all the work are going to be overtaxed. I do not like to see the convention discussions turn the way they have this morning by blaming

it all on the engineer. I think if the travelling engineer paid as much attention to the equipment as they do to the engineer they would find a good field to work in.

C. B. Conger (Locomotive Engineering): I do not know whether we should make any hard and fast rule for engineers to follow in regard to one application or two applications of the brakes when making a stop with a passenger train. You will find that the men who give satisfaction in handling short trains of three to six cares with either method can not do as well with trains of twelve to fifteen cars, they have to fit the method of braking to the train.

If you let off the brakes on a long train of 12 or 15 cars with a few cars with old equipment on them at the rear, these rear cars do not let go as promptly as the head ones and jar the train up; as the head cars are pulled back by the draw head springs as well as the trucks tilting back. With two applications the brake can be released at a speed of 18 to 20 miles an hour and applied again with less force and left set till the stop is made smoothly. In a country where they have slippery rails to contend with on account of mud or other causes, there are a number of slid flat wheels reported which are charged up to the engineer and some of them could be avoided by two applications.

W. O. Taylor (Boston & Maine): I understand that the deliberations of this convention are watched closely by the managements and if they are practicable our suggestions are adopted; but the question has arisen in my mind if it is the sense of this convention to adopt and recommend the two applications instead of the one what effect will that have; now we who are in contact with the men from day to day know that it is a fact that a new idea or change of methods means a revolution in practice; most of us have been taught to make the stops with one application and I think it is time to go cautiously, because of the effect it may have. I may admit that I am in favor of two applications, I believe in it, but I do believe it will be a difficult matter to bring our engineers into that line of practice, as I know it has been on some roads. I should be very modest and not presume to question, but yet from my own experience I do know that no heavy application on a train at high speed can be made without

experiencing a shock, I will speak from a recent experience. I was riding with our Superintendent of Motive Power, the emergency brake was applied and my superior officer and I braced our feet waiting for what might happen; the cause was a bursted hose. Now in educating men to make the stop with two applications approaching the station at a high rate of speed must be left to their judgment while permitting his making a reduction of twelve pounds to get the full application; it depends entirely upon the judgment of that man whether he puts that brake on with a shock. I think that is a point worthy of consideration.

R. E. Webb (Mich. Central): Isn't that shock more mental than physical?

Otto Best (N. C. & St. L.): Would like to inquire if that hose bursted at a water tank or coal shed.

Mr. Taylor: I do not know, there was a shock of the application of the shoes to the wheel, you are all familiar with the noise, then there was a sound next under the body of the car which attracted the attention of the passengers, entirely different from that caused by the service application.

F. B. Farmer (W. A. B. Co.): I have in mind an emergency stop made at 40 miles an hour. I personally noticed and there was not a passenger that paid any attention to it; unless the train came fully to a stop I would not have known whether it was a heavy service or an emergency, unless I had had a recording gauge on or leaned out to see what was the cause of the sudden stop. Another occasion somewhat parallel was where a team was struck; I had a recording gauge sitting on a seat at my side and the jar of the emergency was not enough to move the gauge, a law suit resulted from some one being struck and two passengers stated in court that they were thrown forward in their seats, necessarily they were testifying for the prosecution. No one could have been thrown forward, it was surely in their minds that they were thrown forward.

I would like to put myself on record, not as recommending the universal practice on passenger trains of the two applications, but as advising, first the heavy initial reduction uniform and then if there is danger of sliding wheels, of which nobody knows before, then the second application is desirable.

Mr. Ettinger: I wish to bear Mr. Farmer out in his statement as regards the shock experienced; these are statements that you frequently hear, especially at law suits which men of your type are frequently called upon to give testimony—in defense of the company. You even hear some people swear that there was a severe shock even though the train was running sixty miles an hour. I will say we took a train of five cars and we made a number of tests both at high and low speed, cars that were in good shape; our superintendent who was examining us was surprised to learn there was no severe shock; we not only made one application, but a number of them at different speeds, and it was my experience that we got no shock even as low as six miles an hour; when you are making about two or three miles an hour, that is when you get the shock.

Mr. McAuliffe brought up a train of thought that it seems we are unsettled as to what is desired; why we desire the stops made with two applications, and that it is necessary to talk to the engineer to get him to change his tactics. To begin with I would say, with the two applications you will have more cylinder pressure with the second 10 pound reductions than you will have with the first unless you will allow the piston to return to its natural position; the first ten pounds reduction you make it requires about five pounds of that to force the piston out and fill the vacuum that is caused in the brake cylinder by moving the piston out; the second five pounds will run that pressure up to about 25 pounds cylinder pressure; now if you release that brake and do not give it time for the piston to regain its natural position and immediately follow that with another ten pound reduction, you will get an increase of about 15 pounds, so that point should be watched and allow your brake piston to come back so you do not get a higher cylinder pressure on the second application than you do on the first. Now we have been talking about emergency stops and you will notice, on freight trains particularly, how the men handle the brake; I have been on trains that were handled successfully; just about the time I was beginning to brag of the performance of the engineer, they would come up to a water tank or coal shed and he would make one of those bad stops that would knock all the glory out of the nice work he had done; now the engineer

does not feel that back in the train so much, and I think if it was brought to his mind in the proper light he would cease to do that kind of work; you are not going to accomplish that in a day or two or a month, but if you go to him kindly and say, I wouldn't do that in that way, you can do that with a service application; get him to come up there as he should. Fifteen years experience on an engine leads me to believe that you cannot come up to a water tank or any place and make it with one application and do it right every time; the management orders that stops be made right every time; you are going to come up with one application, you are going to stop a little too soon three times out of five, but if you come up there as you should, releasing your brakes, following it with a light reduction to get your shoes up to the wheel, then you stop right and that is what you will have to do. That has been my experience.

In the use of sand. It may be of interest for some of you to know if a wheel slides on a clean rail it will slide for some distance without any damage whatever to the wheel; I have seen a car weighing over 100,000 pounds on a four wheel truck slide 286 feet and all that could be discovered on the turning of that wheel was a little bright spot.

Now Mr. Hutchins goes after us pretty strong for going after the engineer and lays it to piston travel, but we have not got money enough to put on slack adjusters at present and I will have to say, Mr. Hutchins, that your remarks are very timely; I for one would much prefer to compliment an engineer when he does a nice job; I would rather go over and say, "That is a good job" than to go over and find fault with him; but on the other hand, the piston travel has been watched very closly on our road; three times in 250 miles the Car Department insists on their men taking that travel up, so that they get cared for very closely, and then if slid flat wheels are found on the car, attention is called to the train, and piston travel is taken so we have very good results of the piston travel on our passenger cars. The gentlemen would like to know how we keep a record and charge them up to the engineer. We have a form that is filled out by the Superintendent of the Car Department, information on that is furnished by the various car inspectors at different inspection points, the wheels

are very closely inspected, every wheel that has a spot of an inch on is reported, a record is kept of that, and if the wheel did not have the spot when it left the last terminal it is charged to the engineer between those points.

Mr. Taylor: Do they turn the wheels around to examine them all over to see whether they do not stand on a small spot?

Mr. Ettinger: They "hug" the wheels and find a spot as big as a dime. I think we ought to stick to this slid flat wheel question until it is exhausted. If we are going on record as adopting the two application practice, do so; but hear what every member has to say about it before we go on to anything else.

Mr. Hutchins stated that 12 pounds reduction will not slide wheels; I have seen every wheel under a car slide with a 12 pound reduction where the conditions were bad. On the Missouri roads where the black mud is like grease, every wheel in the car would slide; now the leverage on that car was gone over carefully by two or three Westinghouse assistants and myself and it was found to be all right; the triple valve was in good condition, we know it was in good condition because we had a gauge in that car that dealt with the cylinder pressure, but the wheels slid just the same; those are the conditions that you have to go against.

F. M. Nellis (Westinghouse A. B. Co.): I am rather glad to hear Mr. Hutchins take up the cause of the engineer and sympathize with them; I rather think he gets all that is coming to him in the way of slid flat wheels, for if we have a flat wheel we first look after the triple valve, then the leverage, and if that is all right—then go after the engineer, put it all on him. There is a lot more to be considered to flat wheels; I find a great many of them come in freight and passenger yards; the hand brake is set up on a car and it is pulled around the yard and flat wheels are the result.

Regarding two applications, some five or six years ago the Air Brake Association to a man voted that one application was the proper practice, but about a year ago, having had considerable experience, they voted that the two applications was better than one, generally speaking, not confining this to a universal practice.

In the use of sand, it might be interesting to state that on the New York Central Road they made a number of tests to determine

the value of sand in connection with brake application and the results was interesting; by opening up the sand pipes just as wide as they could be opened and a full flow, they found it much easier to slide wheels than when a little sand was dropped; sand put sparingly on rail would stop the train in 11 per cent. less distance than if there was no sand on the rail.

Mr. Hutchins: Mr. Nellis' remarks recalls to my mind an instance that happened about two weeks ago in New York City in one of the yards there. I was standing talking with an engineer when I saw it; a yard engine got hold of a train and went through the yard with the wheels sliding in four or five places, I watched them down the yard as far as I could see them and the wheels were sliding and the engineer said to me, "The next poor sucker that gets that car out will have slid flat wheels to his credit," and I think that is the cause in a great many instances.

Regarding Mr. Ettinger's remarks about inspecting the piston travel three times in 250 miles, I do not think it applies to all trains as there are some that only make one stop in 250 miles, so he could not apply that rule generally.

Mr. Ettinger: Regarding piston travel I will say, our piston travel on the Wabash is taken at each division where we have inspectors; some divisions are 100 miles, on some 150, between Kansas City and St. Louis, the places we have been talking of, the piston travel is taken three times.

Otto Best (M. E. & St. L.): I think we have gone after the engineer enough, let him live, and let's get after the air brake inspector, keep your air brakes in good shape and I do not think you will have so many flat wheels.

C. H. Weaver (L. S. & M. S.): I have listened very attentively to the very interesting remarks that have been made in regard to the two applications and the sliding of wheels.

I wish to say that several years ago I made a very exhaustive test in relation to slid wheels; we were having at that time an unusual number of slid wheels. It did not seem to be on any one division, but there were a number all over the system, and it was the opinion of our management that the large number of slid wheels was due to the improper braking by the engineer.

I took the opposite view of it, viz: that if the adjustment

and leverage of brakes was proper, and the man used his brakes properly, they should not have slid wheels.

To make this satisfactory to all, I equipped a coach with two gauges, attaching one of them to the brake cylinder and another to the train line. I ran that coach for three or four weeks on the different trains, and took a record of each stop, the amount of cylinder pressure we got, whether it was with one application or two, recording the highest pressure in cylinder, and the amount of train line pressure at the time of the application, and the amount of reduction made, and in no case during time of test was the cylinder pressure higher than fifty-four pounds. We had the brake on that car adjusted to a five-inch piston travel, so as to be sure that the car would have the shortest piston travel in the train; but I will say, bearing Mr. Ettinger's statement out, that wheels slid on that train and on that car in one or two cases where reduction in train line pressure did not exceed ten pounds. The conditions of the rail were favorable for it.

This train was one of the night trains; we were having a good of frosty weather at this time, and we found that the wheels did slide on this train and on the car that I was making the test, with a reduction not to exceed ten to twelve pounds, and there were no instances where the cylinder ever went above fifty-four pounds with a full brake application.

Those records went into the general office, and at that time Mr. A. M. Waitt was our Master Car Builder, and he went over those records, and I think it convinced him, as well as the rest of us, that slid wheels was not due invariably to the engineman.

I will say that enginemen can obviate to some extent slid wheels, if the conditions are conducive to wheel sliding and they know it; then I think it is a good time for him to use two applications of the brakes with the view of eliminating slid wheels.

I suppose that I was one of the first to suggest two applications under certain conditions, brought about by the trouble we were having.

In handling one certain train made up of three or four mail, then came two or three baggage cars and coaches, and sleepers on the rear, the train consisting generally of twelve to fourteen cars; the difficulty to stop smoothly, and in the handling of this train

was not confined to any one point, but at various places over the entire system. It was handled by the best brakemen, and at various times they all had the same trouble that at time of release there was a severe shock felt on the train. They tell us there is no slack in passenger trains, in some there is not, but in the train I have mentioned, the distance between the buffers would be from four to six inches just at time of release, this was due to releasing on about the last turn of the wheels.

The disposition, of course, is for the brakes on the head end of the train to release first, then when that takes place, the slack is pulled out of the train by the brakes not being released on the rear. About the time the train stopped, the brakes on the rear of the train would release, permitting slack to run in so as to make a severe concussion, resulting in a bad stop.

We tried all ways to handle this train successfully, and we found by making two applications of the brakes we had the best results, making initial reduction heavy enough to reduce the speed of the train down to five or six miles an hour; we then released the brakes fully, by throwing the brake valve into release long enough to start all brakes to releasing; the aim was to have the brakes off, or nearly so, within three to five car lengths from where they wanted to make the stop, and then make the final stop with light reduction.

If the speed was reduced sufficiently, the light reduction would be enough to make the stop; you could then release your brakes on the train without any shock, owing to the light cylinder pressure. Of course if we do not get our brakes fully off, we will have a high pressure at the final stop; but the point in making the two applications is to reduce the speed by a high cylinder pressure when the speed of train is greatest, then release and make the final stop with a light reduction; this prevents stretching of train at time of final release on account of light cylinder pressure. We are handling on our road a great many heavy passenger trains as well as freight. On our long freight trains we have anywhere from fifty to seventy-five cars, all or part air; on these trains it is a difficult thing to handle them, and it is a question that is of interest to everyone, particularly so to men of our line of business, as to whether it is a success in handling fifty to seventy car trains under present conditions.

We have had a great many cases of break in two. I equipped our heavy freight engines with pressure retaining valves, removing the weight from the valve, drilling a small hole in the valve, which retards the release of the brake from twenty-five to fifty seconds on the engine. We find by using it in that manner we have better results; still that does not entirely avoid the brake in two, even with the brakes retained in that manner, when the speed of the train gets down to between five and ten miles an hour, we are liable to break in two. In my experience it is not good practice to undertake to release the brakes on a fifty car freight train under a speed of 10 miles an hour, even with the use of the retaining valve as we have in service now. With speeds ranging from that up to fifteen, we have not had any difficulty.

One of our traveling engineers told me that he was on a train where they had seventy-two cars of air; they released the brakes when going about eight miles an hour, and there was no difficulty. Everything being in a favorable condition, that might be all right, but I would not recommend releasing brakes on a train of that length at a speed of less than fifteen miles an hour.

Coming back to the point of two applications and slid wheels, the thing, I believe, should be left largely to judgment of the engineman. It may be under certain conditions that the brake will give better results and make smoother stops with two than with one application; then again we may get the same results, or as good results, with one application. It should be left to the engineer of our passenger trains to make his stops as he sees fit, holding him for good results; he is used to the condition of stops and possibly has to economize on air.

If we can get the results desired by handling trains with one application, I think that would be all right. I do not believe we should enforce any iron clad rules that would compel a man to use two applications under any and all conditions. He should be governed largely by conditions, as to whether it is necessary to make two applications or not. If we have a bad rail, or are liable to come on a muddy road crossing, then we must instruct him it is advisable to make the two applications, so as to have the brake applied light for final stop, making the initial reduction heavy when the speed is high.

I do not believe it would be a good policy to adopt rules that would enforce men to make one or two applications under all conditions. Instruct the men regarding the advantages of two applications with reference to wheel sliding and making smooth stops, permit him to exercise his judgment as to which is the best course to persue, holding him responsible, however, to get good results from his method of braking.

F. B. Farmer: For the object of permitting the Association to assert itself one way or the other, I wish to move on the matter of two applications, which is as follows: Motion, That this Association favors, in passenger service, the use of a somewhat heavy initial service reduction with the object of lessening the maximum amount of pressure reduced, and shortening the time of making the stop. Also, that where the rails favor wheel sliding two applications are best where the second application is light.

Wm. Owens (N. Y. A. B. Co.): I second the motion.

President: It has been moved by Mr. Farmer and seconded by Mr. Owen that this Association favors in passenger service, the use of a somewhat heavy initial service reduction with the object of lessening the maximum amount of pressure reduced and shortening the time of making the stop. Also that where the rails favor wheel sliding two applications are best where the second application is light. All in favor of this motion will signify by the usual sign.

Carried.

The President: Is there anything further on the report?

S. D. Hutchins (Westinghouse A. B. Co.): That is a very unsatisfactory vote.

The President: We will take a standing vote.

A. B. Collins (C. B, & Q.): I am not in favor of making the heavy initial reduction. On some roads where the equipment is such that the lost motion is taken up; a heavy reduction will not make a shock, but where the conditions are such and the brake equipment is in such a condition that a heavy reduction makes a shock, it seems to me that motion should be modified.

F. B. Farmer (Westinghouse A. B. Co.): An endeavor was made to have that somewhat clearer by saying "a somewhat heavy initial reductlon." It could be that the first application could

consist of two or three light reductions, rapidly following each other to accomplish the same result.

C. B. Conger (Locomotive Engineering): As I understand this, it is not for slow moving freight trains; at the speed they are running passenger trains I do not believe the engineer is able to make a sufficient reduction to cause any shock; I have seen trains break in two when they were running at 50 miles an hour and no one knew there was any shock; I do not see why we should pay any particular attention to the heavy or light initial reduction on passenger trains making stops. I favor the resolution exactly as it is, or as I understand, that on *passenger* trains where the rail conditions require that a heavy initial reduction be made to slow the train down, when you move slow enough and are about the right distance from the stopping point, release either partially or fully, at least start all the triple pistons toward the release position, bring your brake valve to lap and immediately make the second reduction, which will be considerably lighter to suit the conditions, it is thus possible to make the stop without having any shock and make your stop just exactly where you want it.

S. D. Hutchins: I may not have gotten the drift of that resolution but as I understand it, or the impression of it is, that the engineer make his stop with no more than two applications.

F. B. Farmer: There are two distinct features comprehended; one is a heavy initial reduction in making stops so as to shorten the time of the stop and reduce the amount of air consumed in making; the second, that where wheel sliding is liable to occur, of which nobody has better information than the engineer, that the two application there is preferable to one; it says nothing about any more than two, it is hardly necessary.

C. H. Hogan: Does it recommend one application only in conditions where the rail is not wet and slippery?

F. B. Farmer: It can be so read if anyone desires it. I will say that was the object of recommending the two applications only where the rail conditions justified it, where the danger of sliding was great.

R. E. Webb (Mich. Central): We receive such ideas as that whether or not we favor them ourselves, and the effect remains

that even though we do not favor the idea, yet on the quiet we will try it just to prove that it is so, and then if we find it so we are all right. I do not believe there will be any great difficulty in adopting the two application principle or style of stopping a passenger train. It is in practice on the road where I am employed and while we were at the offset instructed to use the one application style of stopping, we have found it is better when we have 10 to 14 cars on heavy grades. Just before coming to Cleveland, I was riding on one of our trains, we stopped at Battle Creek with 11 cars, a very fast train, and made two applications. The speed of the train was reduced with the first application, the air was released and the second application stopped the train just where the engineer wished it at the water plug with no shock, and I think there will be no very great difficulty encountered in inducing the locomotive engineers to adopt anything they know to be of value, and I would not be in favor of committing myself to an expression of adopting the one application principle where I know that the two application principle is a pronounced success.

Mr. Benjamin (C. & N. W.): I do not see our air brake representative here at this meeting, but he is instructing us to use the two appplications. I find in riding with some of our men since adopting this instruction that they are doing very successful braking; one man in particular was running by quite frequently, and I said to him, "You do not seem to be running by any more." "Well," he said, "I am using two applications and I find I am doing better braking." Inasmuch as the shock is concerned I cannot say we are experiencing any difficulty in that line on our trains, and we have two that are pretty high speed trains. As far as I am concerned I may say, I favor the two applications, and as for sliding wheels, I do not know what they are on our division.

C. H. Hogan (N. Y. C. & H. R.): By passing this resolution I think we are going on record as recommending one application. Of course you bring in the condition of the rail; that is to be left to the judgment of the engineer. Those of you who have run an engine know the conditions change every day and I do not see how we can afford to go on record as recommending one application for passenger service. So far as leaving it to the judgment of the engineer as regards the condition of the rail, we must do that anyway; that is a thorough understanding.

S. D. Hutchins (W. A. B. Co.): I do not quite agree with Mr. Hogan in regard to the resolution. I do not think that any air brake instructor or traveling engineer instructs an engineer to make all their stops with one application. Our instructions have always been, where trains must stop at a special stop, such as a water tank, the stop can be made very successfully with two applications and I think it is the proper way to stop a train. Two applications should be applied always. The first application should be released a sufficient distance from the specified spot to allow the brakes to release and to be caught up again with a light application. I do not think there is anyone skillful enough to always make a specified stop with one application. Stops where you have from 25 to 50 feet leeway, the one application of the brakes would be the most skillful way of stopping the train, but as I understand the resolution now, I think it is all right; that it provides for one application or two applications in cases that I have just cited.

C. F. Schraag (M. K. & T.): I think I understood Mr. Farmer to say two applications are recommended. I do not believe in telling engineers to do one thing at that time and another thing at another, and if it is left to them and they slide wheels, what then? Suppose a man makes a light application and makes it too light, now as the speed reduces he is afraid to make too heavy a reduction for fear he will stop too soon. Now by allowing them to make two applications they can run closer to the station before they need apply the second heavy reduction, for the reason they are not going to stop at any one speed; they can release the brake and then make a light application and stop just where they want to. In that way they stop sooner; they get away from the station sooner on account of their releasing the brake soon enough, and for that reason I was in favor of two applications and I voted for that. I thought it was what it meant.

Asa Sawyer (L. S. & M. S.): I have been on the Lake Shore for thirty-seven years and I have run all the fast trains we have had. I have had the best success with making two applications. Of course there are times when you can get into a station with one application, but a great many times you get fooled on that. The best success I have had has been with two applications.

Clinton Decker (M. & O.): We instruct our men to stop with two applications and we have no slid wheels; you will find it is not hard to interest the men; we do not make any stops with passenger trains except with two applications and I think if they will do that it will be a big advantage to them.

The President: Mr. Farmer's motion is now more fully understood, we are ready for the question; all those in favor of the motion will rise; we will have a standing vote.

37 stood up.

The President: All those not in favor of this motion will please rise.

13 stood up.

Motion carried.

The President: Is there anything further on this subject?

S. B. Hutchins: I move that the question be closed.

Seconded and carried.

The President: We have the report from the committe regarding the joint meeting of the two associations and Mr. Thompson will read it.

MR. PRESIDENT AND GENTLEMEN:—The Committee reports that they were unable to make a recommendation as to a joint meeting of the A. B. A. and T. E. A. for the reason that they were evenly divided for and against a joint meeting of the association, the interests of both being in remaining as at present. The hotel accommodations as a rule would be inadequate for the large number that would attend either association; who held their meeting first would leave the balance of the week for the other at a time when several of the members would be tired out and desirous of returning to their homes, leaving the convention before the conclusion of the work, which would prove unsatisfactory and unprofitable to both associations.

W. G. WALLACE,
C. H. HOGAN,
C. B. CONGER,
Committee.

F. M. Nellis: I would like to say a word. It is the proper report and anybody who has sat in a convention for six days will know it is. At first I was in favor of the two associations meeting at the same time, one following the other closely, but I think that the committee's report is just right, and I hope that nobody will bring it up again, and I think it should be dropped. If anybody else brings it up in the future he should be talked to.

The President: I think it is about time the subject was disposed of for good.

C. B. Conger: I am one of the members of that committee. I signed the report because that is the way the committee felt about it. I feel there is a sentiment among the railroad officials that the men who attend both conventions get off a week in the fall and one in the spring, and that if the meetings were held one after the other they could attend both meetings in one week. The traveling engineer can attend such meetings of the air brake men as they see fit, while the general men are the only ones that will have to put in the whole week. I am one of the general men, belonging to both associations. I am both an air brake man and a traveling engineer. But there are a great many objections to having the two meetings together. The Air Brake Association are now holding their conventions in the spring, the Traveling Engineers' in the fall, and they are not disposed to have their time of meeting changed. There was a letter ballott taken two or three years ago and there were 60 per cent of the members voted for September and October and only 40 per cent voted for any other time, and I do not believe the air brake men will change from spring to fall. If we should meet together we would have to change the date of meeting, and that we cannot do very well. They would also have to make arrangements for a larger attendance than we have at present and the towns that we meet in may not be able to accommodate us and for a number of such reasons I expect when the question comes up to vote that it be vetoed until we get a new regime in here that has not gone through some of the experiences we have. After the next generation comes up of traveling engineers and air brake men, it will be all right for them to discuss it.

S. D. Hutchins: I move we adopt the report.

The President: Gentlemen, you have heard the motion by Mr. Hutchins, seconded by Mr. Long that the report be adopted, all those in favor give the usual sign.

Carried.

The President: The next paper to be read for discussion is the third printed report "The use of the Steam Engine Indicator as an aid to the Traveling Engineer to determine the efficiency of

the locomotive in service, and the benefits derived therefrom." When this paper comes up for discussion, which will be tomorrow morning, if there are any questions to be asked on number three, Mr. Wildin will be here to answer them.

I understand that Grand Chief P, M. Arthur of the B. of L. E., will meet with us tomorrow morning. Ninety per cent. of our members are members of the Brotherhood of Locomotive Engineers, and we will be pleased to meet Mr. Arthur.

I understand the boat ride is off for this afternoon owing to the storm on the lake.

F. M. Nellis: I move we adjourn until tomorrow morning.

D. Meadows: I second the motion.

Carried.

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## Third Session.

THURSDAY, September 13, 1900.

President Stack called the meeting to order at 9.20 A. M.

President: This meeting will now come to order. We will call on Mr. Wildin, chairman of the Committee on the report to be discussed this morning; the report to be discussed this morning is, "The use of the Steam Engine Indicator as an Aid to the Traveling Engineer to Determine the Efficiency of the Locomotive in Service, and the Benefits Derived Therefrom." Mr. Wildin will answer any questions that you would like to ask on the subject.

Mr. Wildin read the report as follows:

## The Use of the Steam Engine Indicator as an Aid to the Traveling Engineer to Determine the Efficiency of the Locomotive in Service, and the Benefits Derived Therefrom.

# PART I.

*To the President and Members of the Traveling Engineers' Association:*

Your committee appointed to investigate and report upon the above subject, beg to submit the following as a consensus of their opinions and the results of their labor. We find that the steam engine indicator is about as old an instrument, historically, as the steam engine itself, the former having been invented and the latter perfected by that pioneer of steam study, James Watt, whose labor was ceaseless in the interest of steam engineering, from his advent into the mechanical walks of life in 1755, until his death, which occurred in 1816.

Notwithstanding the fact that the two machines were almost simultaneous in origin, and should have been inseparable during the march of economical improvements in steam engines, we find the steam engine and its functions thoroughly understood and made use of by millions, while the indicator and its functions are understood and appreciated by comparatively few.

Of those who have made use of the instrument in a practical way, the vast majority have limited their labor and researches to stationary work, and but a very few indeed have made any attempt to expand the locomotive literature upon this subject. We, as members of this Association and Traveling Engineers, are interested, pure and simple, in the instrument as applied to the locomotive, and the deductions we may make from the lines it will record when applied in the proper manner and guided by competent hands. In view of the above fact, your committee has as far as possible, consistent with clearness, avoided the use of cuts, illustrations, and terms made use of in stationary work, which were not found essential or had a close bearing upon the subject in hand.

The limited extent to which the indicator is used at present among railway motive power men seems to be due, as far as your committee has been able to ascertain, to three principal causes.

The *First*, and probably the greatest reason, is the general lack of appreciation of the utility of the instrument among that class of railway mechanical men who have the power to authorize its application to locomotives under their jurisdiction.

*Second*; there seems to be a general opinion prevailing, that the problem of applying the indicator to a locomotive is a difficult one, and to solve it requires the employment of an expert. This, together with the first reason given, has done much to keep the indicator in the background and make it unpopular in locomotive work.

A *Third* reason we might mention as exerting quite an influence in keeping the indicator from entering the field of locomotive work, and has certainly caused it to be thought of as being especially fitted for technical schools and scientific men rather than for practical road tests to be carried out by practical men, is the fact that those versed in the use of the indicator and the knowledge it imparts, have as a rule, surrounded their teachings and recommendations with such a multiplicity of details and suggestions, that the ordinary individual cannot comprehend them, and if they were understood it would be utterly impossible to follow them out in actual service. The consequences are we give up in despair and keep on doing as our fathers did.

The object sought by your committee in preparing this report has not been to unearth new and unheard of things in connection with the use of the indicator on locomotives, but to arrange such information as we felt would be beneficial to the members of this Association in such shape as to enable any member, if he so desires, to proceed and indicate a locomotive in the proper manner, and make the correct deductions from the reading of the cards.

Those unacquainted with the instrument seem to look upon it as possessing a certain something, they call mystery, which is not for them but for others to solve. We feel quite positive that a large majority of the Traveling Engineers on our railroads to-day could with but a very little effort and study indicate intelligently the locomotives under their charge, and thereby save a great deal of money for the company and anxiety and trouble for themselves.

The indicator should be looked upon in connection with locomotives as bearing the same relation to the cylinders as the steam gauge bears to the boiler or the air gauge to the main reservoir and train line. It is simply a pressure gauge and nothing more. Our ability to locate the cause which produces a certain undesirable effect upon the lines of the diagram, measures our fitness as the proper person to handle the indicator.

The data necessary to be taken while on the road testing an engine, in order that proper calculations may be made, is very little, and can be gathered and recorded by an apprentice from the shops, or a fireman from the road, whom the Traveling Engineer should take along as an assistant. As Traveling Engineers we are not concerned in locomotive tests to such an extent as to require us to record an endless mass of details and data, such as has been usually recommended. For our purpose we want nothing but what is practical in ordinary every day locomotive work, and we want these practical results with the employment of the least force and expenditure of time and money possible. If the indicator is ever to become popular in locomotive work it must come about through the elimination of useless details.

The general impression among those who are competent to judge is that

the cause of the indicator, in connection with the locomotive, has been injured by too much detail work. In this connection an article appeared recently in a prominent railway paper dealing with this subject from which we quote extracts below, as we believe it, coming from the source it did, reflects the sentiment of the practical mechanical men of our railways, and it certainly voices the sentiments of your committee.

"Several years ago a most elaborate report was made to the Railway Master Mechanics' Association on the testing of locomotives, which if carried out would require an army of experts and would bring out a volume of information that no one would derive the least benefit from, and which would throw no useful light upon the working of the engine. We do not believe that any person ever attempted to follow the elaborate tests recommended in that report, but we think that it has stood as a barrier in the way of making a few simple tests necessary to find out whether an engine is using the steam properly in the cylinders.

"Nearly all railroad companies ought to make the steam-engine indicator a useful tool in daily use to find out defects of locomotives; but when the officials read statements from learned men telling that tests cannot be properly made without the presence and aid of a host of scientists, they conclude to endure the evils they know the weight of rather than to shoulder unknown ones that may crush out their official existence.

"On nearly all steamboats the steam-engine indicator is applied to the engines once a watch, or at least once a day. Two men at most are required to do the work of taking the indicator diagrams. Very little data are taken beyond working out the horse-power developed in the various cylinders, and noting any distortion due to defects, which would be remedied at the end of the voyage. The engineers who manage these engines are practical men who do not care a cent for finding out 'hifalutin' data. They merely want to record how the engines work and to put on their log indications of deterioration. To them the indications of a leaky valve or piston are important; they care nothing about how far the temperature of the steam may be above the freezing point. The same plan ought to be followed by locomotives, and it ought to be carried out daily and systematically. A traveling engineer and an assistant ought to be all the force necessary to do the work. If they recorded the boiler pressure and the revolutions per minute, the indicator diagrams would tell all that was worth knowing. The presence of leaky valves, leaky pistons, too much back pressure or excessive compression, would all be indicated by the diagram, and the remedies could be applied when the oportunity came. If that simple practice were generally followed, it would greatly profit railroad companies, for it would point out the leading defects of engines that were running down, and the practical men in charge would apply the remedies that would save many tons of coal.

"The indicator applied to locomotives in the sensible manner it is applied to marine engines would make its use popular. Requiring that its application should involve a mass of data of no practical utility is calculated to make the instrument unpopular, and has done so for years."

Your committee feels that if through the medium of the material and suggestions contained in this report, they can succeed to any degree in breaking down the barriers which have been erected in the path of the indicator's entrance into the locomotive field, and may help to popularize its use among that class of men who above all others should learn to use it intelligently, viz: The Traveling Engineers, they shall have accomplished the purpose for which they were appointed.

In attempting to collect material for this report, your committee prepared a list of questions comprising fifteen which covered the ground quite thoroughly, and through which we hoped to ascertain the extent to which the steam-engine indicator had been used by the members of the Association, in order that we might incorporate such matters as would impart the greatest good to the greatest number. To these questions we received, from a membership of something like three hundred, eleven replies, nearly all to the effect that little or no experience whatever was had. Acting upon the assumption that these replies were a fair representation of the entire membership of the Association, your committee has incorporated many features in this report that might have been omitted had the answers to the questions indicated a more general acquaintance with the indicator, its uses and benefits.

It will be understood that this report is not intended for the scientific but for the members of The Traveling Engineers' Association and practical mechanics. We have tried to put things in the most practical light.

The report will be found to be divided into four parts. Part I. deals with the indicator and simple engines.

Part II. takes up the compound engines and the application of the instrument to them.

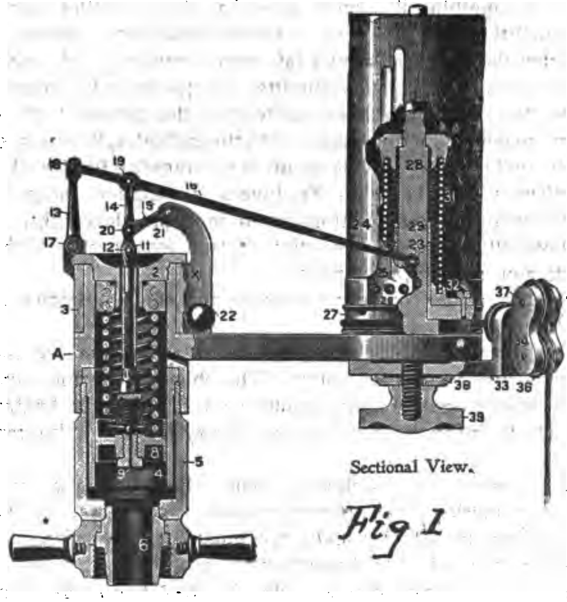
Part III. consists of tables and useful formula convenient to use in making calculations and comparing results. The object in placing such material in this report was in order that any member not having a mechanical library might have all the information at hand necessary for calculating results after making tests.

Part IV. contains cuts, descriptions, explanations and instructions as to the use, care and merits of the different makes of indicators, and the several calculating instruments which usually accompany it. By reference to Part IV. any member may select for himself such an outfit as he may wish, and find the price with the instruments so that he may know the approximate cost of the outfit.

Your committee wishes to acknowledge its indebtedness to several parties for their generous co-operation in assisting the committee in its work. Especially do we wish to mention "The Ashcroft Manufacturing Company" and "The Crosby Steam Gauge and Valve Company" for their assistance in furnishing the cuts and material for Part IV. S. M. Vauclain, General Supt. Baldwin Locomotive Works, C. J. Mellin, Chief Engineer Richmond Locomotive and Machine Works, and The Schenectady Locomotive Works, for their contributions in Part II. Richard A. Smart, Associate Professor of Experimental Engineering, Purdue University, for his valuable contribution

included in Part I. Mr. Smart made several tests for the committee to illustrate the effect certain changes would make upon the outline of the card. We wanted certain information which could be obtained accurately from the testing plant at Purdue University, and which would have been impossible to get in road service on account of the difficulty in getting the conditions to agree in all particulars.

The first knowledge the Traveling Engineer should acquire, is that regarding the mechanism of the indicator, and how to maintain it in perfect condition in order that the results obtained may be relied upon.




Sectional View.

Fig 1

Figure 1 is a sectional view of a representative instrument and shows very well the principle upon which all indicators are constructed. By supposing pressure from the cylinder to enter the instrument through cavity 6, against the under side of the piston and then trace the effect through the compression of the spring in the other moving parts, it will be easy to understand how and why the indicator produces such a card as it does.

Figure 2 is a card taken from one end of a cylinder of a 20"x26" ten wheel freight engine with 60" driving wheels. The scale of spring was 80, the miles per hour 20, and the boiler pressure 175 pounds.

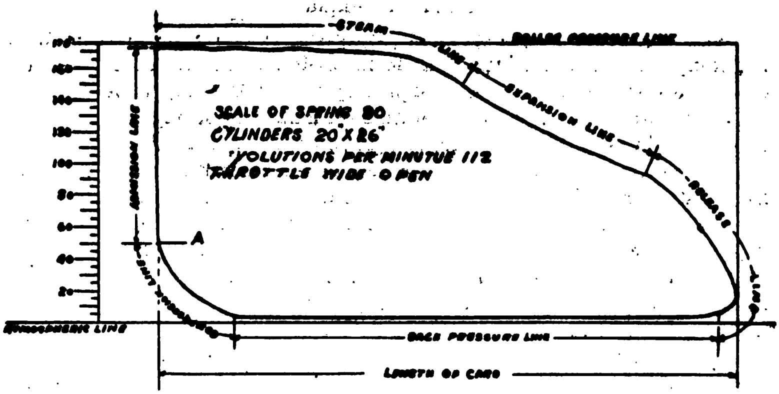



*Fig. 2*

The spaces included between the arrow points represent the duration of the different lines of the stroke as we pass around, commencing at the point "A". The names given them are their proper ones and we should make ourselves familiar with them. The events of the stroke as shown by this card are very distinct and easily recognized, but as the revolutions per minute increase the difficulty of locating these points also increases. This fact is illustrated very forcibly by the series of cards shown on Plate IV.

Figure 3, Plate I, gives the correct method of locating the events of the stroke and they are marked both in per cent. of the stroke and in inches.

## TESTS MADE FOR THE COMMITTEE AT PURDUE UNIVERSITY.

(Plates I to VII, inclusive.)

Concerning this work Professor Smart writes as follows :

"For a number of years the department of Mechanical Engineering of Purdue University has had, as a part of its material equipment, a plant for the testing of locomotives. This plant was the first of its kind and was an unique departure from the ordinary method of testing locomotives on the road. In the years which the plant has been in operation a great deal of valuable information regarding locomotive economy and locomotive practice has been secured. In securing this information the indicator has played a necessary and highly important part. In fact, without the indicator it would have been impossible to secure much of the data which has been derived from the plant.

It is thought that a brief statement of some of the results of the indicator work on this testing plant may be of interest and service to the Association in connection with the report of this committee. Many of the statements herein contained are doubtless well known to many, if not all, of the members of the Association. They are, however, worth calling attention to in this connection.

SCALE OF SPRING.

The best scale of spring used in any given case depends largely upon two things: The maximum pressure in the cylinders, and the speed. With a low speed it is desirable to use as light a spring as is compatable with the steam pressure in the cylinders. With most makes of springs, the scale of spring should be such that the maximum pencil movement will not be over an inch and three quarters. While it may be known that the cards are to be taken with a partially open throttle, it is usually safer to assume that full boiler pressure may be used in the cylinder, and to choose a spring accordingly. As the speed of rotation increases it is better to use a stiffer spring in order to obtain a smooth card. It is the practice of the Purdue laboratory to use a spring ranging from 80 to 150 pounds per inch, according to the steam pressure at which the engine is to be run.

There is a tendency on the part of some to neglect the effect of a stiffer or weaker spring in a cursory examination of different cards, and to assume that a large card always means a large mean effective pressure and large horse power, but this is not the case, as is readily seen from Figures 1 and 2, Plate I, which are cards from the locomotive under identical conditions but with different springs. Figure 2 is taken with an 80 pound, and Figure 1 with a 150 pound spring.

LOCATING EVENTS OF STROKE.

Figure 3, Plate I, shows the correct method of locating the events of stroke, namely: Cut-off, release, compression and admission. There is a general tendency to locate the point of cut-off at some point higher than that shown by Figure 3. This, however, is not correct. The point of cut-off is that point at which the indicator pencil as it leaves the admission line reaches the hyperbolic curve which is concave upwards. Similarly, the point of release is at the end of the hyperbolic curve and where the reverse or convex curve begins which leads to the back pressure line. The point of compression is usually very difficult to locate. Care should be taken that the point selected is sufficiently removed from the back pressure line and not at the point where the curve starts upward from the back pressure line.

EXCESSIVE AND NEGATIVE LEAD.

Figures 4 and 5, Plate II, show the form of card obtained where the lead is excessive and where it is zero or negative. The exact form of the card will vary in different cases, but the indications as to the amount of lead are usually unmistakable. The loop at the top of the card in Figure 4, is probably due to inertia in the indicator parts.

THE EFFECT OF LONG INDICATOR PIPES.

One of the most serious troubles in connection with the use of indicators on the road is that it is ordinarily not possible to place the indicators in as close connection with the cylinders as is possible on a stationary testing plant. The pipes leading up to the indicator are usually from three to four feet in length. That this has a marked effect upon the form of the card, especially

# PLATE-I.

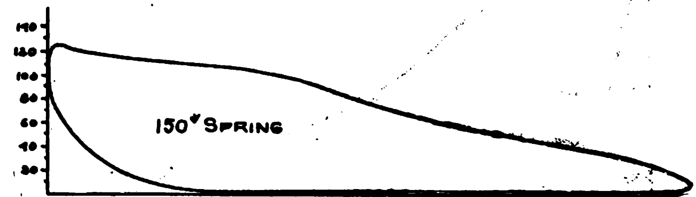



FIG. 1. HEAVY SPRING

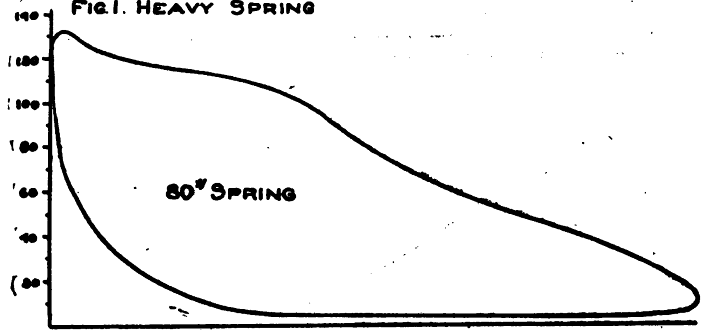



FIG. 2. LIGHT SPRING.

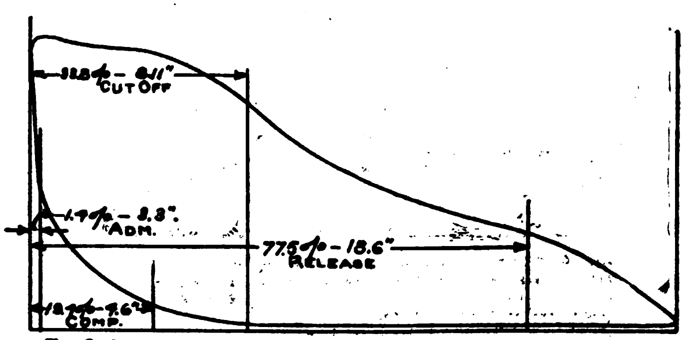



FIG. 3. METHOD OF LOCATING EVENTS OF STROKE.

# PLATE-II.

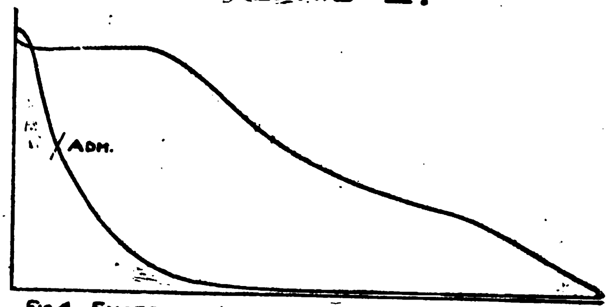



FIG. 4. EXCESSIVE LEAD.

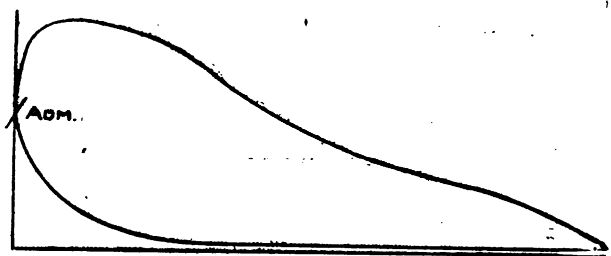



FIG. 5. NO LEAD.

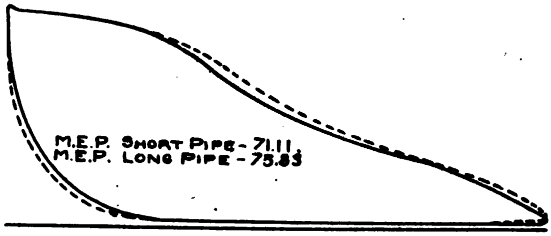



FIG. 6. EFFECT OF LONG INDICATOR PIPE
FULL LINE SHOWS CARD TAKEN WITH SHORT PIPE.
DOTTED LINE SHOWS SIMULTANEOUS CARD TAKEN WITH 5-FOOT PIPE.
SPEED-37 M.P.H. R.P.M.-200.

at high speed, is beyond doubt. In Figure 6, Plate 2, is shown the effect of taking a card through a five foot pipe of the usual size. The full line shows the normal card taken with a short connection, and the dotted line shows a card taken simultaneously with the first one but with a five foot pipe between the cylinder and the indicator. The increase in the mean effective pressure is from 71.11 pounds to 75.83 pounds, or 6.6 per cent. The speed of rotation was 37 miles per hour, or about 200 R. P. M. At a higher speed the discrepancy would have been greater, and at a lower speed it would have been somewhat less. With a three foot pipe the difference would have been less than that shown at the same speed, but would still have been an amount which would not be negligible. Under ordinary conditions the effect of lengthening the pipe is to increase the size of the card. Under certain unusual conditions the reverse might be true.

The point which should be observed in this connection is that an effort should be made to keep the pipes as short and as direct as possible, and, further, that cards taken with long pipes at speeds of over 25 or 30 miles an hour, are only approximately correct.

### CARDS AT DIFFERENT CUT-OFFS.

On Plate III is shown a series of three cards, Figures 7, 8 and 9, taken at the same speed, and with the same steam pressure, but at different cut-offs. The effect of shortening the cut-off upon the other events of stroke, particularly upon the lead, should be noticed.

This series shows very clearly that it is not safe to set the valve in any notch far removed from that in which the engine is expected to do most of its running. For instance, the valve may be set to give a good distribution at one-half stroke, and such a setting will, at one-third stroke, where the engine may do most of its running, give an excessive lead and one detrimental to power and economy. This argues strongly against the practice of setting a valve by giving a certain amount of lead in the corner notch and without investigating any shorter cut-offs, as is sometimes the practice.

### CARDS AT DIFFERENT SPEEDS.

On Plate 4 is shown a series of five cards with the same cut-off and the same boiler pressure but with different speeds of rotation, varying from 15 to 55 miles per hour. The reverse lever was in the same notch for all cards. This shows very clearly the distortion of the valve motion as the speed of rotation increases. It will be seen that on account of this distortion, and of the wire drawing of steam through the ports, the mean effective pressure decreased from about 62 pounds to about 24 pounds. The amount of this decrease in any given engine would depend on the condition of the valve gear, the weight of the valve itself and the lubrication. As would naturally be expected, there would be less distortion with a strong and well made valve gear, a light valve and an ample quantity of lubrication.

This series shows very plainly the necessity of taking the speed into account when judging of the correct setting of any valve from the card. It also shows very forcibly the impossibility of judging of the steam distribu-

# PLATE - III.

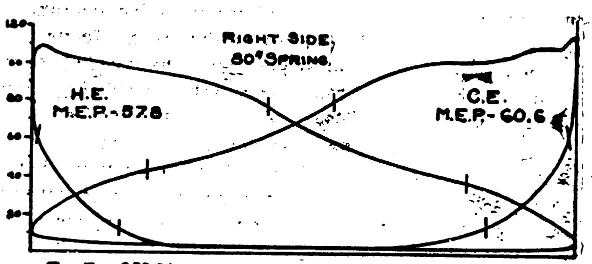



FIG. 7. 3RD NOTCH.

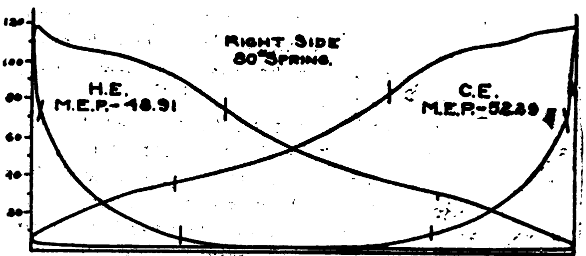



FIG. 8. 2ND NOTCH.

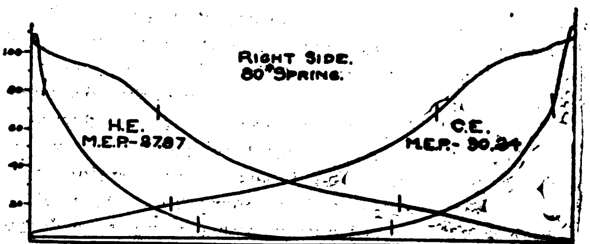



FIG. 9. 1ST NOTCH

CARDS SHOWING EFFECT OF
CHANGE OF CUT OFF.
SPEED 25 M.P.H. 134 R.P.M.

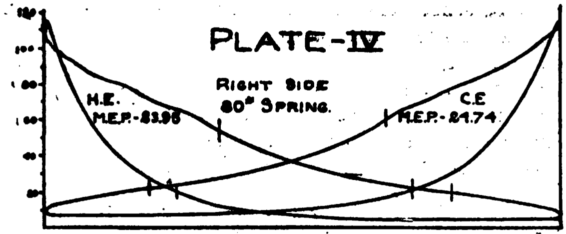



FIG.10. SPEED 55 M.P.H. 300 R.P.M.

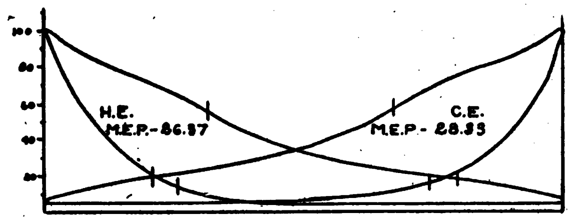



FIG.11. SPEED 45 M.P.H. 243 R.P.M.

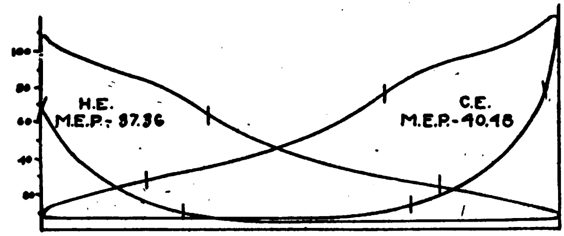



FIG.12. SPEED 35 M.P.H 190 R.P.M

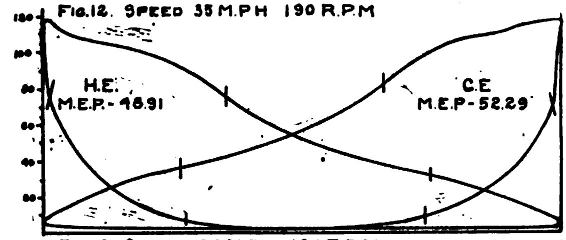



FIG.13. SPEED 25 M.P.H. 134 R.P.M.

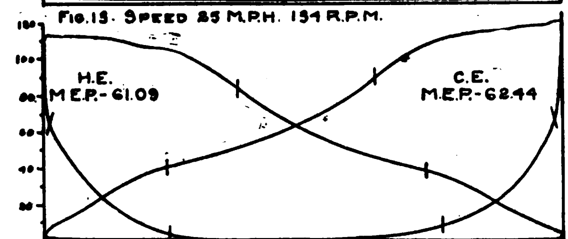



FIG.14. SPEED 15 M.P.H. 81 R.P.M.

tion, say of a passenger engine, when under high speed, by the ordinary method of measuring the valve performance in the shop, or even by taking cards at very slow speeds. An engine may show a good distribution with any position of the reverse lever when she is rolled slowly over by hand in the shop, and she may give a very poor distribution in the same notch when under steam on the road. This, doubtless, accounts for the failure of many engines in service to make schedule time.

THE EFFECT OF INSUFFICIENT LUBRICATION.

Figures 15 and 16, Plate 5, were taken from the same indicator during the same run and about thirty minutes apart. Figure 15 shows the normal card. Figure 16 shows the effect of insufficient lubrication. The cards are shown to call attention to the serious distortion which may occur to the valve motion even though the setting be nominally correct.

CARDS AT LONG CUT-OFF.

Figure 17 shows a card taken from the tenth notch at a speed of 35 miles per hour. The chief point of interest is the choking of the exhaust and the consequent raising of the back pressure to something over 20 pounds. In this instance the nozzle and the exhaust passages were too small to allow proper egress of the steam under the condition. The condition was, of course, abnormal and the tip and passages were amply large for all ordinary cut-offs.

This illustrates, in an exaggerated way, what will happen when the exhaust passages or the tips are smaller than they should be.

THE ALLEN-PORTED VALVE.

Figures 18 and 19, on Plate 6, illustrate the difference between a card taken with a plain valve and one taken with an Allen-ported valve under similar conditions. The card shown in Figure 19, taken with the Allen-ported valve, is slightly fuller than that in Figure 18 and has an M. E. P., which is 4.69 pounds higher.

# PLATE-V

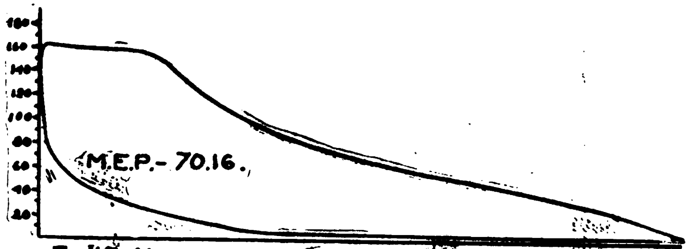



FIG. 15. NORMAL CARD

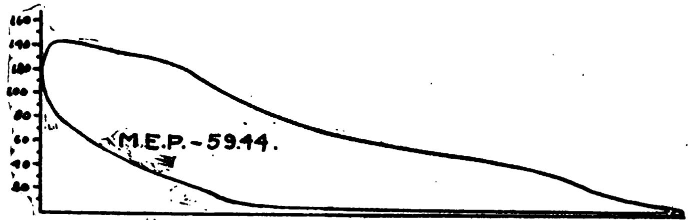



FIG. 16. INSUFFICIENT LUBRICATION.

CARDS SHOWING EFFECT OF INSUFFICIENT LUBRICATION.

ALLEN RICHARDSON VALVE.
R.P.M.-121.5.
SPRING-150#.
STEAM PRESSURE-210#

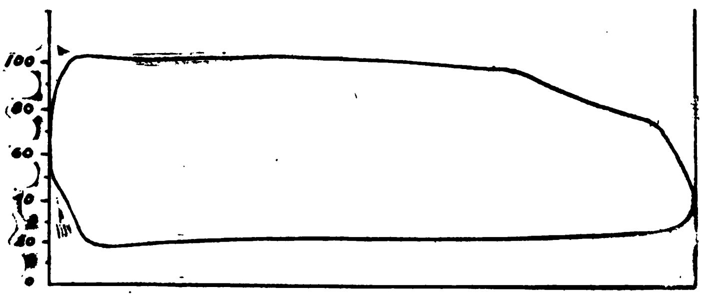



FIG. 17. CARD SHOWING EFFECT OF CHOKED EXHAUST.
10TH NOTCH. 35 M.P.H.

# PLATE-VI.

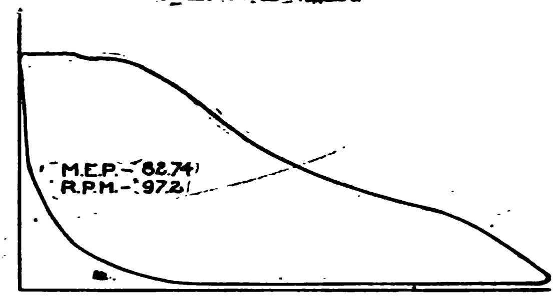



FIG. 18. ALLEN PORT PLUGGED

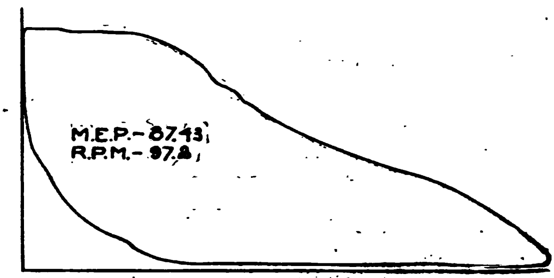



FIG. 19. ALLEN PORT OPEN.

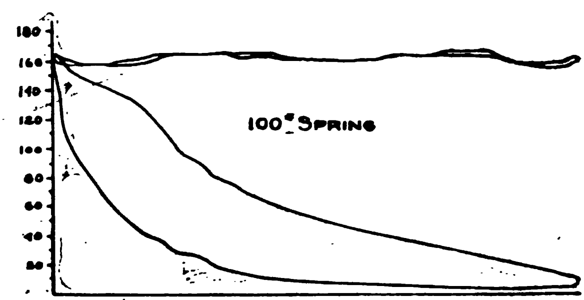



FIG. 20. SHOWING CARD FROM STEAM CHEST.
SPEED-20 M.P.H.- R.P.M. 97.2.

The amount of this increase of mean effective pressure varies with the valve setting, the speed, etc. The characteristic feature of the card taken with the Allen-ported valve is the wave in the expansion and compression curves at points a and b. The wave at point a is caused by the cutting off of the steam in the Allen port from that in the cylinder during the early part of expansion. The wave at point b is caused by the opening of communication between the Allen port and the compression side of the cylinder when the former is full of steam at boiler pressure. The wave on the compression curve is usually the more prominent of the two, and sometimes may be seen when the other is indistinguishable.

VARIATION OF PRESSURE IN THE STEAM CHEST.

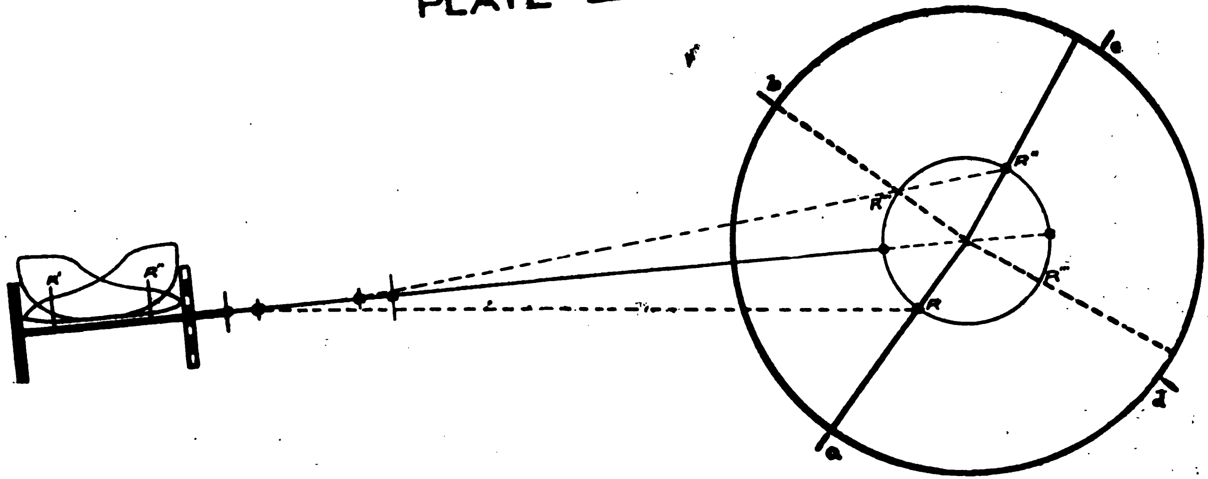
In Figure 20, Plate 6, is shown a card from the steam chest, together with the corresponding card from one end of the cylinder. It will serve to give an idea of the momentary drop in pressure caused by the successive admission of steam to the ends of each cylinder. The effect of the admission on each end of the cylinder on the other side is seen in the drop in the middle of both branches of the steam chest card.

EFFECT OF THE CONNECTING-ROD IN SECURING A "SQUARE" ENGINE.

Nearly every locomotive runner has a desire to have his machine sound "square," on the supposition that this condition denotes an equal distribution of steam in the cylinders. In reality, if the point of release, or exhaust opening at the cylinders, occurs at equal portions of the piston travel on the four ends, the exhaust will not sound square at the stack on account of the angularity of the connecting-rod. This is illustrated on Plate 7. The dotted positions of the connecting-rod and crank pin R′ and R″ are those corresponding to the equal release points R′ and R″ as marked on the indicator. Similarly, crank pin positions R‴ and R⁗ are those for the other side of the locomotive when the piston is in the two release positions.

It will be seen that these crank pin positions do not compare with the 90 degree points on the driver, a, b, c and d, which are laid off for convenience, beginning with crank position R′. This shows that if the release of steam occurs at equal piston positions on the four ends, the engine will sound a little "lame" and, conversely, if the engine sounds "square," the release is not equal on the four ends. In other words, a "square" engine does not mean an equal distribution of steam in the cylinders.

PLATE- VII.



Attention was called to Figures 1 and 2, Plate 1, to illustrate the fact that it was quite necessary in examining a card to take into consideration the scale of the indicator spring with which the card was taken.

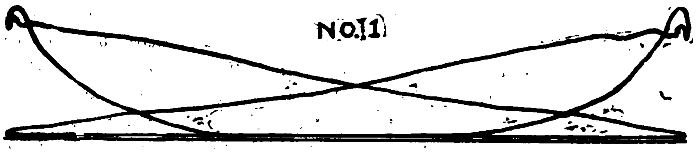
We wish to call your attention to cards 3 and 4, Plate VIII., which you will observe bear about the same resemblance to each other as do cards 1 and 2, Plate I., and yet cards 3 and 4 were taken with the same identical spring, which was of 80 pounds tension, the speed in each case being 42 miles per hour, and the boiler pressure 165 pounds. The back pressure line of card 3 is about one-half the distance away from the atmospheric line as the back pressure line of card 4. In this case the back pressure per square inch is only one-half as much in card 3 as in card 4, while in the case of cards 1 and 2, Plate I., the back pressure per square inch is the same. Results such as shown in Plate VIII. can be produced by simply opening your throttle valve wide or partially closing it.

In order to avoid confusion in reading cards, the tension of the spring and the position of the throttle should never be omitted.

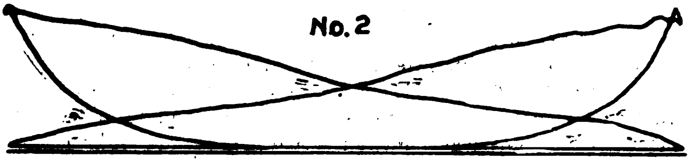
Cards 1 and 2, Plate VIII., furnish good examples of *wire drawn steam* caused by a partially closed throttle valve. The same results would be obtained if we should place enough restriction in either of the following passages: *First*, in the stand pipe; second, in the dry pipe; third, in the steam pipes, and fourth, in the steam passages between the steam pipes and the steam chest. Were the steam ports insufficient, the steam line would have a very rapid decline from the point of initial pressure to the point of cut-off. Cases are on record where in casting steam pipes a large piece of the core fell out in handling and was unnoticed. When the casting was poured iron took the place of that portion of the core which was gone and caused a stricture in the steam pipe. With an engine with one steam pipe restricted and the other of the proper size, the skill of the best mechanic in existence would be baffled in trying to square an engine by the train method. One side of the engine would give a card similar to No. 4, Plate VIII., while the other would give one similar to either 1, 2 or 3, depending upon the amount of stricture. This defect is easily discovered by taking a steam chest card, and if the line of the card drops very rapidly at the time the cylinder is taking steam it is evident that the steam is entering the cylinder faster than it is being supplied to the steam chest, consequently there is an insufficient steam passage somewhere between the steam chest and the boiler, and a search will have to be made to locate it. Cards 1 and 2, Plate VIII., illustrate another point very forcibly and that is that excessive compression cannot be eliminated by throttling the steam. This is quite evident when we remember that excessive compression is the result of compressing the steam remaining in the cylinder, when the exhaust closure takes place, until it exceeds that in the steam chest. The speed or revolutions per minute has quite a governing influence on compression. Card 2 shows excessive compression to a small degree at a speed of 45 miles per hour and 175 pounds boiler pressure, while card 1 shows it to a very great degree at a speed of 52 miles per hour and the same boiler pressure. In this connection your at-

PLATE VIII

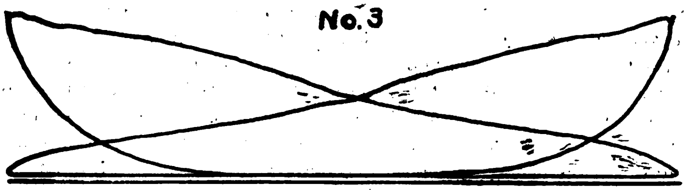
No. 1



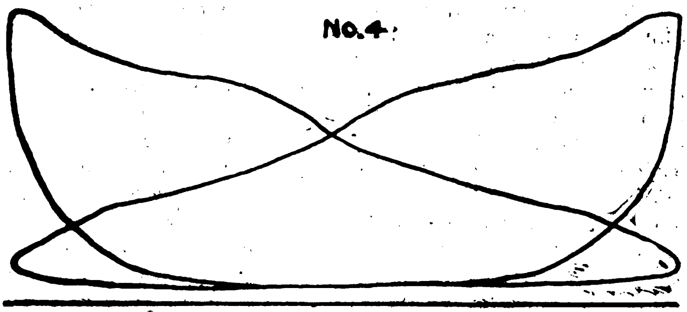
No. 2



No. 3



No. 4



tention is again called to Plate IV., in which all conditions are equal except that of speed. The loop on Figure 1 is caused by excessive compression.

A small exhaust nozzle will aid in producing excessive compression at high speeds. Anything, in fact, which reduces the clearance space, or will cause a greater quantity of steam to be imprisoned in the cylinder at the time of the exhaust closure, will assist compression.

## THE INDICATOR AND THE EXHAUST NOZZLE.

The office of the exhaust nozzle in a locomotive is two-fold. First, to guide the exhaust steam from the cylinder to the atmosphere: and second, to create a draught upon the fire.

A third function which it performs is one which we would be glad to eliminate entirely if we could only do so, that of producing back pressure in the cylinders. The majority of men handling engines find no difficulty in telling when an engine is choked, or cramped as they sometimes say. While they may always tell when an engine is cramped, they do not appreciate the loss of power due to cramping. Your committee does not care to go on record as advocating the abolition of the bridge in all cases, for we know that there are times when it may be necessary, as an expedient, to get over the road. We do believe, however, that many nozzles are bridged to get the steam out of an engine when it could just as well be had by a good, common sense design, of the front end arrangement, exhaust pipe and smoke stack. When steam is secured through the latter method it is not at the expense of the power of the engine. The promiscuous, unintelligent practice of bridging the nozzles at present on many roads is a pernicuous practice, and should be discouraged as much as possible.

Figure 3, and the deductions which follow, are submitted to emphasize and make clear the committee's views expressed in the foregoing remarks.

Fig. 3

These cards were taken from a ten wheel passenger engine with 19"x26" cylinders and 69" driving wheels. The speed was 41 miles per hour, boiler pressure 170 pounds, and the scale of the indicator spring 80.

The engine in question was equipped with a variable nozzle device, consisting of a simple ¾" triangular bridge with its apex turned down, which could be placed across the tip of the nozzle or removed as desired by the engineer from the cab. A ¾" bridge has just enough square inches of area to compensate for the difference between a 5" and a 5½" single tip nozzle.

Figure 3 was produced as follows: Everything being in readiness, a card was taken with the bridge removed, the result being the card with the greatest outline. Instantly the nozzle was bridged and another card taken on the same paper and over the first one, the result being a card which coincided at every point, except the back pressure line, with the first one. The increase in back pressure is due solely to the influence of the bridge. The compression line is also affected.

The effect upon the power of the engine under the two conditions is clearly shown by comparing the calculations made from the two cards:

| | *Open Nozzle.* | *Bridged Nozzle.* | *Difference.* |
|---|---|---|---|
| M. E. P......... | 62.8 pounds..... | 56. pounds .... | 6.8 pounds |
| Area of Card.... | 3.50 sq. inches.. | 3.19 sq. inches.. | .31 sq inches |
| I. H. P......... | 932.80 ........... | 825.74............ | 107 |

The cards shown are from one end of the cylinder only, but the figures here given for H. P. represent the total H. P. developed by the engine under the two conditions.

By the simple introduction into the nozzle of a ¾" bridge we reduced our total H. P. 11.3%, or nearly ⅛, which is quite a loss of power.

Now if we consider these figures in another light we will see more clearly the effect the ¾" bridge has upon the engine's capacity to handle trains. We must determine the decrease in pounds of tractive power or pull upon the draw bar.

By referring to the formula given in part III. of this report relating to the Tractive Power Constant we find that an engine of the proportions of the one from which these cards were taken, has a tractive power per pound of M. E. P. of 136 pounds. This means that for every pound of M. E. P. acting upon the piston we get a pull on the draw-bar of 136 pounds.

With the cards in question we have for the open nozzle a M. E. P. of 62.8 pounds, and for the closed nozzle 56 pounds. Hence, in case of the former, we have a pull on the draw-bar of 8,541 pounds, and with the latter we get only 7,616 pounds, a difference of 925 pounds. The most reliable formula we have for calculating the resistance per ton at various speeds, gives as the resistance at a speed of 41 miles per hour 12.25 pounds on straight and level track. From this we find the capacity of this engine for handling a train on straight and level track at a speed of 41 miles per hour reduced 75.51 tons, which is about equivalent to 1½ Pullman sleepers.

What has been said concerning the bridging of nozzles will apply

equally well to small nozzles unbridged. Your committee appreciates the fact that there is a limit to the size of nozzles, governed by the quality of the fuel, etc., beyond which you cannot go. We are not making a stand against necessary small nozzles, but against carelessly small ones. In support of our position in this matter, we cite Figures 4 and 5 as good examples of what can be done in the way of increasing the power of the engine by simply supplying it with the proper size nozzle. The reduction in back pressure was brought about by substituting a 5¼″ nozzle for a 4¾″ one, all other conditions being equal.

Figure 4 shows a back pressure on an average of about 22 pounds, while the back pressure in Figure 5 is only 10 pounds, a difference of 12 pounds per square inch.

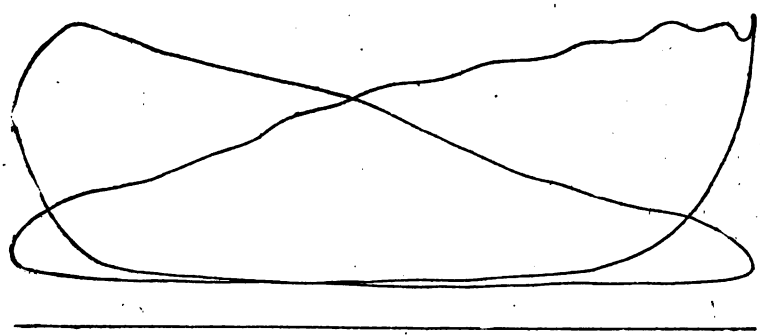


FIG. 4.

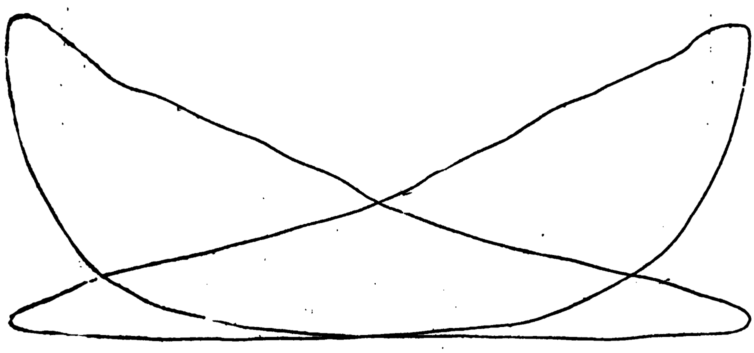


FIG. 5.

The engine from which these cards were taken is of the same class as the one previously mentioned, consequently we have for every pound of M. E. P. 136 pounds pull on the draw-bar. We would have then as an increase of power, had the line in Figure 4 been reduced to 10 pounds, 12 times 136, or 1,632 pounds. The speed in miles per hour was 55; the resistance per ton at this speed is 15.75 pounds. Then 1,632 divided by 15.75, equals 104.26 tons increased pull on the draw-bar, which is equivalent to two Pullman sleepers.

No tangible reason could be found for using the 4¾-inch rather than the 5¼ inch nozzle, except to compensate for poor and extremely heavy firing, which will always grow out of the use of a very small nozzle.

The engine in question steamed very well with a 5¼-inch nozzle when fired properly, and many pounds of coal were saved.

An indicator card if taken at slow speeds with a long cut-off and throttle wide open, will usually tell whether the openings in the exhaust base have the proper proportion to the tip of the nozzle.

If the area of the openings in the base taken separately are equal to or greater than the area of the tip of the nozzle, a card similar to Figure 6 will be the result. This card clearly shows that the exhaust from one cylinder has gone over into the other momentarily, in consequence of the openings in the exhaust base being of greater area than the tip itself. Steam, like all imprisoned gases, escapes through the easiest channel. Where double nozzles are used this effect of back-lash will never occur.

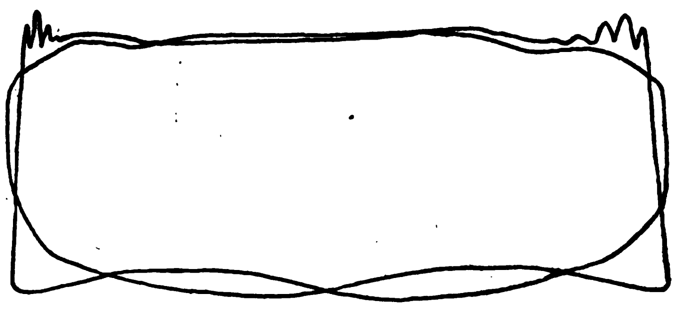


*Fig. 6*

The cards illustrated in Figure 6 contain about all the defects possible to secure on a single pair of cards. They are shining examples of the following defects: Valves very blind. Back-lash or exhaust from one cylinder to the other. Moisture or water in the cylinders. Excessive back pressure. No compression and no well-defined events of the stroke, such as admission, cut-off and release.

About the only good thing we can say about these cards is that they furnished the committee the example they were looking for.

**Your attention in connection with this subject is again called to Plate V., Figure 17.**

THE INDICATOR AND VALVE SETTING.

The valve motion of an engine constitute its lungs, and when the valves inhale and exhale steam, they are either breathing economy or extravagance.

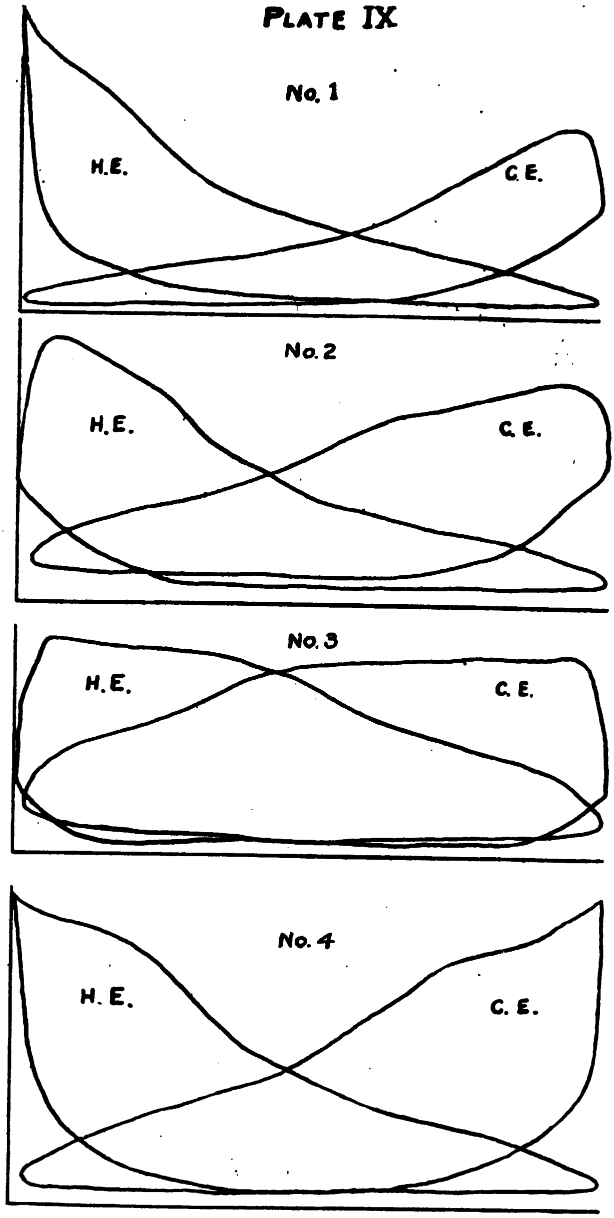
The time-honored custom of setting the valves with the reverse lever in the corner notch and expecting from them an economical distribution of steam at all speeds and cut-offs, must give way to a more rational method of adjustment, that of setting them from data taken while working under full pressure of steam, and at a speed at which the engine is expected to do the greatest percentage of its work. The effects of speed and cut-off upon cards have been illustrated in another part of this paper. There are defects in the valve gear of all engines which will not manifest themselves so as to be detected by the tram method, but when on the road working under pressure are very pronounced. We refer to the spring and vibration of the different parts. Every official having supervision over the motive power on a road ought to know beyond a doubt what degree of economy he is getting out of his engines. The only direct and infallible way to obtain the desired information is through the judicious use of the indicator. It is not enough to compare one engine with another. Each engine should be judged from the facts revealed by the indicator, when the engine is working under normal conditions.

The series of four cards shown on Plate IX. furnished good examples of what can be accomplished in the way of getting proper steam distribution, and an increased efficiency of an engine through the medium of the indicator at a trifling cost. They were all taken from a 10-wheel engine with 20 x 24-inch cylinders and 56-inch driving wheels. These charges were made while the engine was in actual service handling a freight train between terminals. The method adopted in making the changes is somewhat novel and not at all difficult. A description of the procedure may be interesting to the members.

The force required to do the work was the operator and a machinist. Card 1 was taken, and revealed the fact that the engine was blind at the crank end and had slightly too much lead at the head end—what we would call out of "square". In a case such as the one in hand the first move to be made is to "square" the engine. A meeting point was to be made at a station ahead. The machinist got his hammer and wrench in readiness and the moment the train stopped on the siding was under the engine. The blade bolts were loosened and the go-ahead blade shortened, the amount being guessed at. By the time we were ready to start every thing was in shape for a second trial. Card 2 was the result of this trial. The result as seen is two blind ends, but of unequal blindness, consequently the engine is still not "square." At the next stop, which was for water, the go-ahead blade was made a little shorter. Card 3 was the result of this adjustment, which shows a fairly square engine, but very blind. The next operation, which was done on a sidetrack, was to give the eccentric a little more angular advance. This was done, and the last trial produced Card 4, a very good card, but to the trained eye reveals the presence of a little too much lead. This was remedied by adjusting the eccentric slightly when the key was fitted at the terminal.

It will be interesting as well as beneficial to follow in detail the changes in power of the two ends of the cylinder, due to adjustment.

PLATE IX



In Card 1 the head end shows a much stronger engine than the crank end, while in Card 4 the conditions are reversed.

CARD 1.

Speed in miles per hour........................ 36
Revolutions per minute........................216
Boiler pressure........................160
Scale of spring........................ 80
Throttle wide open.

| | *Head end.* | *Crank end.* | *Difference.* |
|---|---|---|---|
| M. E. P. | 48.8 pounds.... | 35.8 pounds.... | 13. pounds. |
| Area | 2.42 sq. inch.... | 1.80 sq. inch.... | .62 sq. in. |
| I. H. P. | 401.33 | 285.37 | 115.76. |

CARD 2.

Speed in miles per hour........................ 40
Revolutions per minute........................240
Boiler pressure........................160
Scale of spring........................ 80
Throttle wide open.

| | *Head end.* | *Crank end.* | *Difference.* |
|---|---|---|---|
| M. E. P. | 59. pounds.... | 58.40 pounds.... | .60 pounds. |
| Area | 3.08 sq. inch.... | 3.00 sq. inch.... | .08 sq. in. |
| I. H. P. | 539.45 | 526.47 | 12.98. |

CARD 3.

Speed in miles per hour........................ 19
Revolutions per minute........................112
Boiler pressure........................160
Scale of spring........................ 80
Throttle wide open.

| | *Head end.* | *Crank end.* | *Difference.* |
|---|---|---|---|
| M. E. P. | 75.6 pounds.... | 81.6 pounds.... | 6.0 pounds. |
| Area | 3.85 sq. inch.... | 4.13 sq. inch.... | .28 sq. in. |
| I. H. P. | 328.33 | 343.54 | 15.21. |

CARD 4.

Speed in miles per hour........................ 38
Revolutions per minute........................228
Boiler pressure........................170
Scale of spring........................ 80
Throttle wide open.

| | *Head end.* | *Crank end.* | *Difference.* |
|---|---|---|---|
| M. E. P. | 69. pounds.... | 73.2 pounds.... | 4.2 pounds. |
| Area | 3.40 sq. inch.... | 3.70 sq. inch.... | .30 sq. in. |
| I. H. P. | 599.64 | 616.35 | 16.71. |

Plate X. and Plate XI. are to be considered together. One shows cards taken as the engine had been running for some time, while the other shows the result of nozzle and valve adjustment.

The cards on Plate X. were taken from the engine with adjustment as follows, 1-32 inch blind, full gear, for the front port, and ⅛-inch blind for the back port. The nozzle was 4¾-inch. The cards on Plate XI. were produced with the following adjustment: Lead in full gear 1-32 inch, at 7-inch cut-off 9-32 inch. The nozzle in this case was increased to 5¼-inch.

Attention is called to the enormous back pressure of the cards on Plate X., all due to a small exhaust nozzle. Had the stricture in the exhaust passage existed in the cylinders the back pressure could not have been lowered by increasing the size of the nozzle, and this is the proper test to make before condemning the cylinders to see that the fault is not in the nozzle.

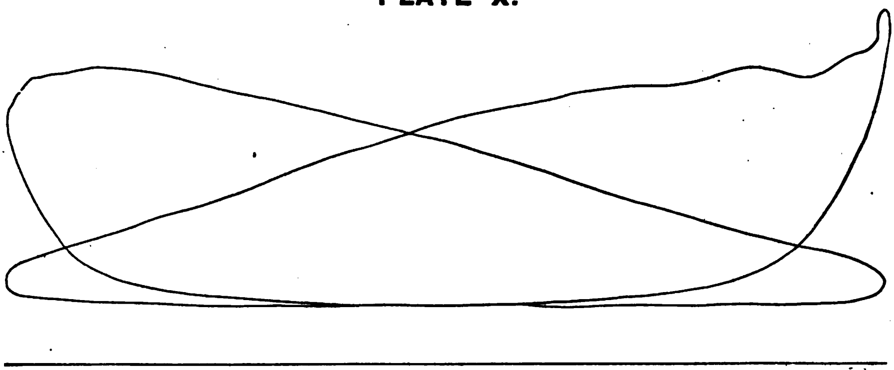
During the trip the cards on Plate X. were taken, six hours and twenty minutes were used as running time over a distance of 211 miles, an average speed of 33.5 miles per hour. On this occasion 12,000 pounds of coal and 9,520 gallons of water were used; making 35 miles per ton of coal and an evaporation of 6.6 pounds of water per pound of coal.

When the cards on Plate XI. were taken the same distance in the same direction, and with the same total tonnage (275 tons) was made in the running time of four hours and fifty minutes, making the average speed 43.6 miles per hour. This trip, 12,000 pounds of coal and 9,680 gallons of water were used. This is 35 miles per ton of coal and an evaporation of 6.7 pounds of water per pound of coal.

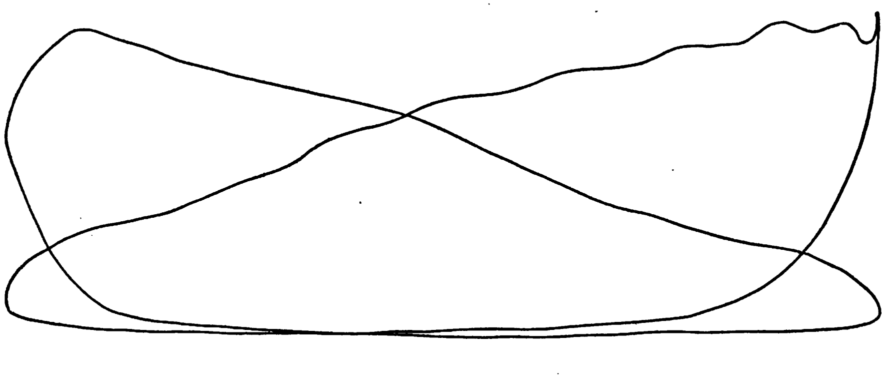
We increased the speed ten miles per hour without adding any expense. Exactly such practical results as these are what we expect to obtain by a proper use of the indicator. For more detailed information concerning these cards you are referred to the July issue of "Locomotive Engineering."

( Plates X and XI on following pages. )

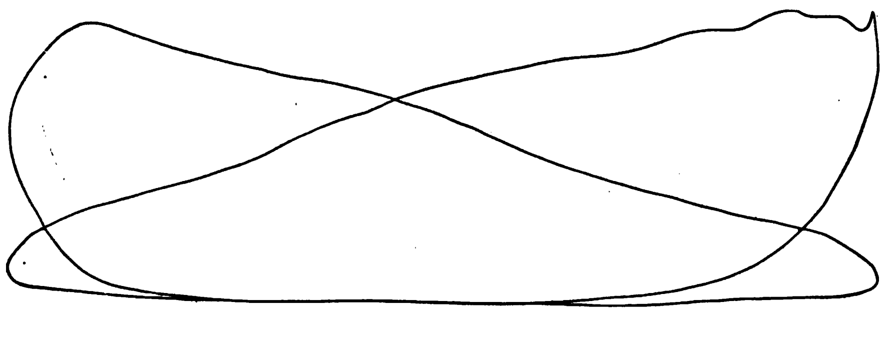
## PLATE X.



NO. 1—REV., 293; BOILER PRESSURE, 170.

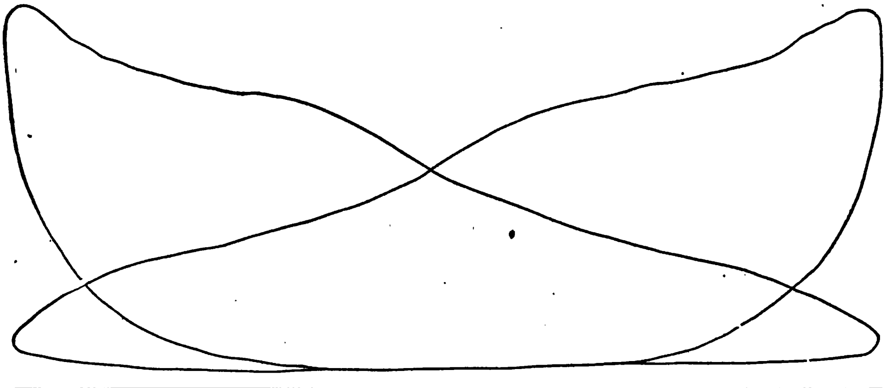


No. 2—Rev., 269; Boiler Pressure, 160.

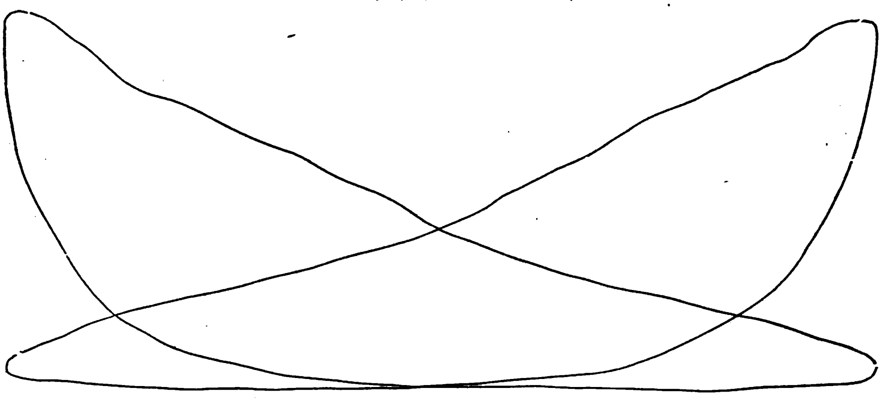


No. 3—Rev., 220; Boiler Pressure, 165.

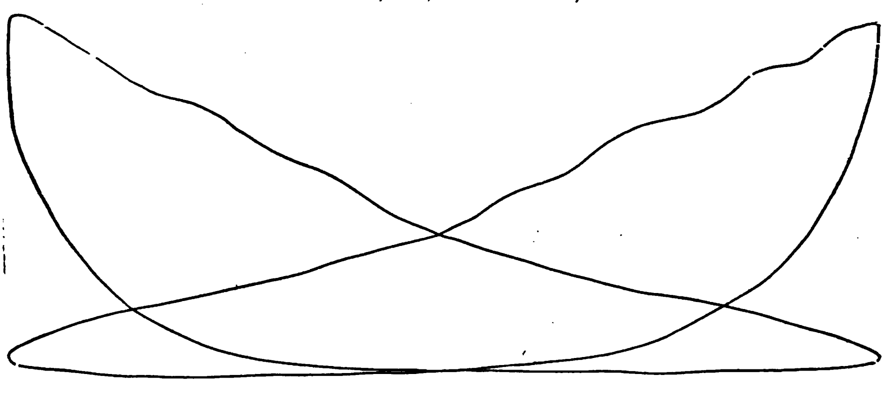
# PLATE XI.



No. 1—Rev., 298; Boiler Pressure, 160.



No. 2—Rev., 269; Boiler Pressure, 160.

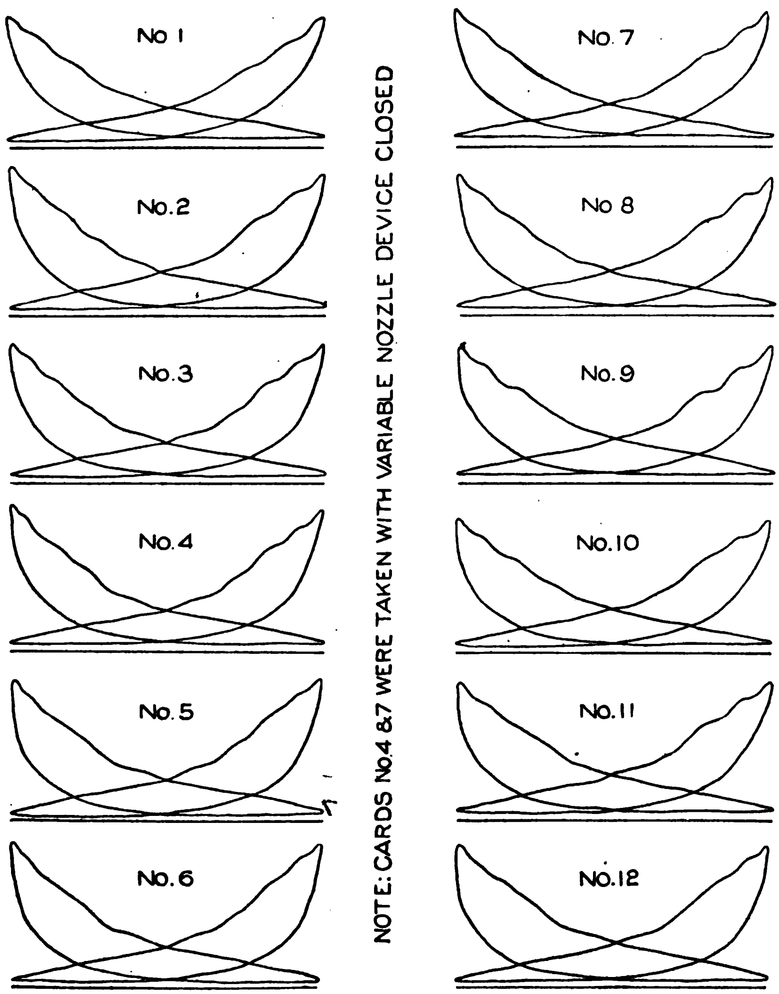


No. 3—Rev., 220; Boiler Pressure, 150.

# PLATE XII.

**INDICATOR DIAGRAMS.—Taken from Engine No. 522. Weight of engine, 115 tons; drivers, 69 inches; piston, 19x26; scale of spring, 80.**

| Card No. | Wt. of train in tons. | Total wt. E. & T. in tons. | Speed per hr. miles. | Rev. per minute. | Boiler press. lbs. | M. E. pressure. Lbs. | I. H. P. of engine. | T. P. per lb. of M. E. P. | Ratio of G. A. to H. S. | Ratio of ext. flue area to f. box area. | Miles run per ton of coal used. | Gal. of water used pr mile run. | Ratio in lbs. coal used to water used. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 325 | 440 | 74 | 361 | 165 | 33.3 | 894.94 | 135.81 | 1 to 73.25 | 11.8 to 1 | 35.00 | 52 | 1 to 7.1 |
| 2 | " | " | 70 | 341 | 170 | 41.0 | 1041.25 | " | " | " | " | " | " |
| 3 | " | " | 65 | 317 | 165 | 39.0 | 920.80 | " | " | " | " | " | " |
| 4 | " | " | 60 | 292 | 170 | 29.0 | 847.75 | " | " | " | " | " | " |
| 5 | " | " | 60 | 292 | 170 | 42.0 | 912.92 | " | " | " | " | " | " |
| 6 | " | " | 58 | 283 | 170 | 41.0 | 860.92 | " | " | " | " | " | " |
| 7 | 375 | 490 | 74 | 361 | 170 | 34.0 | 907.70 | " | " | " | " | 53 | 1 to 7.4 |
| 8 | " | " | 74 | 361 | 170 | 38.0 | 1021.25 | " | " | " | " | " | " |
| 9 | " | " | 74 | 361 | 160 | 38.5 | 1034.68 | " | " | " | " | " | " |
| 10 | " | " | 73 | 356 | 160 | 38.0 | 1007.54 | " | " | " | " | " | " |
| 11 | " | " | 70 | 341 | 170 | 39.0 | 990.50 | " | " | " | " | " | " |
| 12 | " | " | 68 | 331 | 170 | 44.5 | 1099.00 | " | " | " | " | " | " |




( For Diagram see next page. )

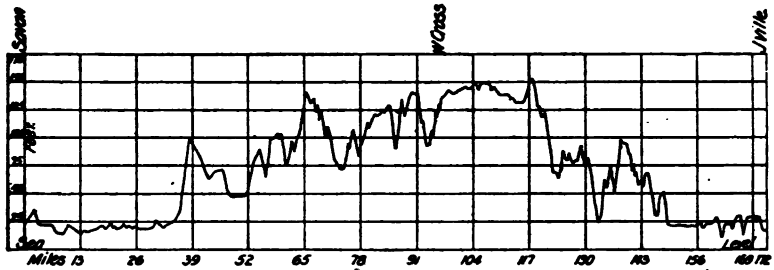



Plate XII. is inserted to show what may be termed excellent high speed cards. Smoother outlines could have been secured by the use of an indicator spring of higher tension.

The method of tabulating the data and calculations is very convenient and simple.

Underneath the card is the profile of the stretch of road over which they were taken. The first six going over the road from north to south, and the last six from south to north.

## EFFECTS OF SPEED ON COMPRESSION.

Figures 7, 8 and 9 illustrate the fact that valves adjusted for a given speed are not correctly adjusted for higher speeds.

Figure 7 was taken at a speed of 74 miles per hour, with boiler pressure of 160 pounds. This card shows two defects excessive, compression 15 pounds* above boiler pressure and a weak indicator spring (80).

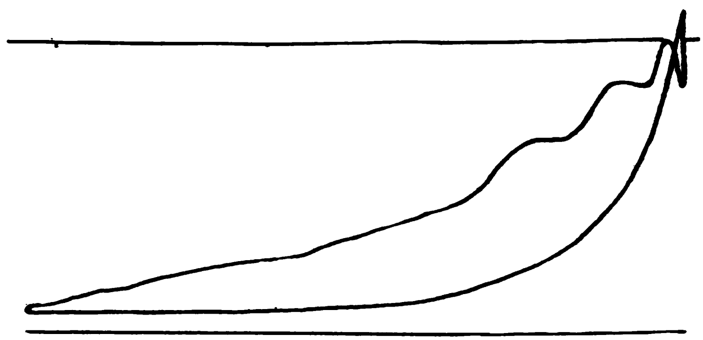


Fig. 7

*NOTE.—A part of this rise above boiler pressure is no doubt due to the *inertia* of the parts of the indicator, but not all.

Figure 8 shows the same defects at 65 miles per hour and 170 pounds boiler pressure. We find the compression in this case 7 pounds above boiler pressure. The indicator spring is still too weak.

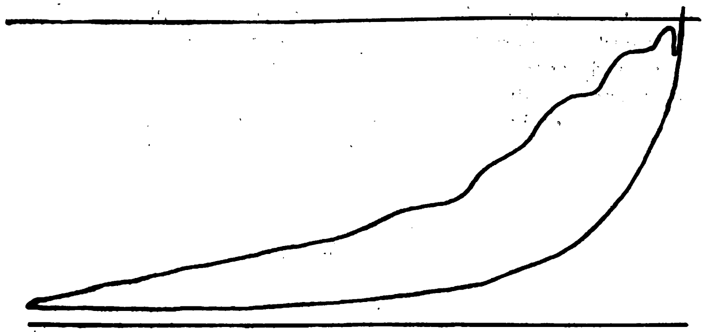


Fig. 8

Figure 9 shows that at 55 miles per hour and a boiler pressure of 175 pounds, an indicator spring of 80 is too weak. This card shows that 55 miles per hour is the maximum speed with the valves as adjusted. We can see very plainly how inefficient the tram method of setting valves would be for high speeds; it can only be a guess at the best.

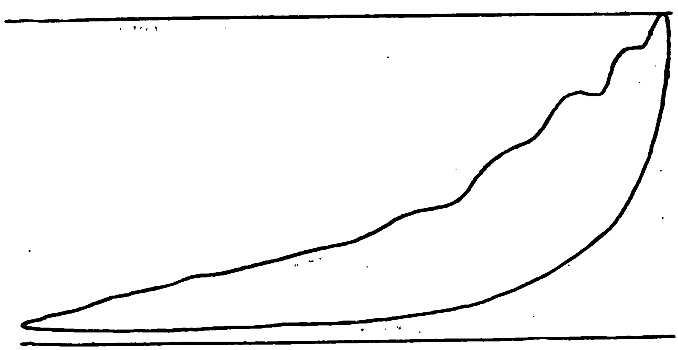


Fig. 9

Slight difficulty may be experienced sometimes in distinguishing from the form of the loop at the top of the card, between excessive lead and excessive compression. Your committee in looking over Professor Smart's contribution came across Figure 4, Plate II., which he uses to illustrate ex-

cessive lead. We noticed a very gradual curve which resembles very closely a compression curve. To make sure that no error had been made your committee asked Professor Smart why he attributed the form of this card to excessive lead rather than compression, and his reply is here given:

"I have your favor of the 18th inst., and note the questions which you ask in regard to Figure 4. I attribute the form of the card in Figure 4 to excessive lead, for two reasons: First, because the slight jog in the card at the point marked 'admission' proclaimed the fact that admission took place there; and, second, that valve diagrams taken with a special diagraming machine, showed that admission occurred at this point. I have no cards showing excessive compression. I would say, however, that were this the case, the form of the card would be but slightly different. The curve would be a little more regular than the one shown, and the loop would be much the same. I have, however, never had difficulty in distinguishing between the form of card for excessive lead and that for excessive compression."

The distinguishing feature is the one mentioned by Professor Smart. A more or less abrupt turn in the curve of the diagram if lead exists, whereas the line would have a gradual curve if caused by compression.

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# PART II.

## COMPOUND LOCOMOTIVES.

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### The Schenectady Compound, by the Schenectady Locomotive Works.

CARDS FROM A TEN WHEEL COMPOUND LOCOMOTIVE.

Cylinders, 21″ and 32″ by 26″ stroke.
Driving wheels, 63″ diameter.
Travel of Valve, 6″.
Outside lap of valve, H. P. 1¼″, L. P. 1⅛″.
Inside clearance of valve, H. P. ¼″, L. P. ¼″.
Scale of indicator spring, 100.

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### Representative Cards from Sheet No. 545.

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SCHENECTADY LOCOMOTIVE WORKS.

USE OF THE INDICATOR.

SCHENECTADY, N. Y., June 6th, 1900.

*Mr. G. W. Wildin, Chairman, Savannah, Ga.*

DEAR SIR: We have a letter of May 31st signed by your committee of The Traveling Engineers' Association, relating to the use of the steam engine indicator, and beg to send you herewith blueprint No. 545, showing indicator cards taken from Boston & Maine locomotive No. 774, built by us. These

indicator cards were considered very good, and are favorable examples of what can be expected in the way of indicator cards when parts are in good condition.

Regarding the manner of connecting indicators to compound locomotives, would say that the indicators are piped in the same way as on the simple engine, except that cards are taken simultaneously on each side of the locomotive, signals being given from the cab, generally by the bell, so that each operator takes the card at the same moment. The indicators connect to a four-way cock placed on top of the steam chest and connected so that the steam chest or receiver pressure can be taken if desired. These lines, however, are not shown on the diagrams given on print 545. We indicate both sides with 100 lb. springs, as this gives a better relative indication of the pressures. There is no objection that we know of to using a lighter spring on the low pressure side if desired.

Some of the defects which can be detected by the indicator cards relate largely to the original design of the locomotive, and would not be a question of adjustment. For instance, if the receiver is too small it is likely to be shown by an undue variation in the back pressure line of the high pressure cylinder, and in the forward pressure line of the low pressure cylinder. Serious leakage can, of course, be detected by variations in the cards from the true form. The effect of inside clearance can be accurately judged. Thus, the effect of inside clearance at slow speeds is shown on some of the cards of print 545. Notice card 2 at point marked "A." If very serious leakage exists in high pressure valve or in high pressure piston rings it will be apt to show an undue proportion of work on the low pressure side of the locomotive.

Yours very truly,

THE SCHENECTADY LOCOMOTIVE WORKS.

J. E. S.

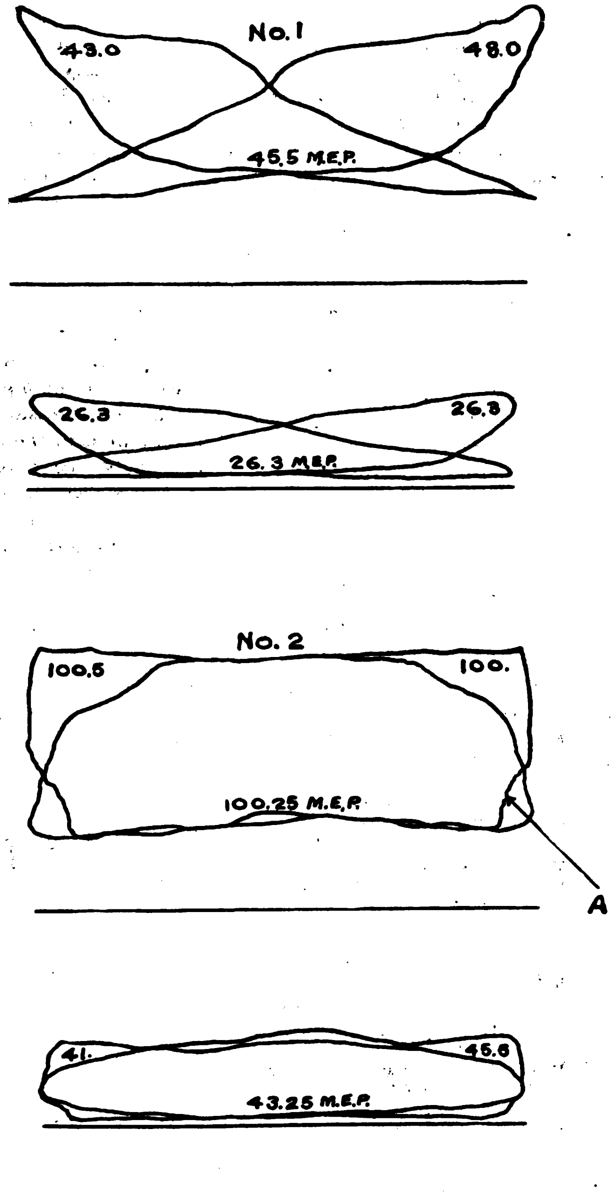
CARD NO. 1, PLATE.

| | |
|---|---|
| Revolutions per minute | 180 |
| Miles per hour | 33.48 |
| Piston speed, in feet, per minute | 780 |
| Boiler pressure | 190 pounds |
| Indicated horse power | 859 |
| Work done by low pressure cylinder | 57.6% |
| Position of throttle | Wide open |
| Tractive power | 9698 pounds |
| Mean effective pressure | H. P., 45.5 lbs.; L. P., 26.3 pounds |

CARD NO. 2, PLATE I.

| | |
|---|---|
| Revolutions per minute | 70 |
| Miles per hour | 13.4 |
| Piston speed, in feet, per minute | 303.50 |
| Boiler pressure | 178 pounds |
| Indicated horse power | 628.50 |
| Work done by low pressure cylinder | 50.4% |
| Position of throttle | ½ open |
| Tractive power | 18262 pounds |
| Mean effective pressure | H. P., 100.25 lbs.; L. P., 43.25 pounds |

# PLATE I


No. 1
43.0
48.0
45.5 M.E.P.
26.3
26.3
26.3 M.E.P.
No. 2
100.5
100.
100.25 M.E.P.
A
41.
45.6
43.25 M.E.P.

## The Richmond Compound Locomotive, by C. J. Mellin, Chief Engineer of the Works.

RICHMOND LOCOMOTIVE AND MACHINE WORKS.

RICHMOND, Va., July 13th, 1900.

*Mr. G. W. Wildin, Chairman, Savannah, Ga.*

DEAR SIR: Replying to your letter of the 1st inst., I take pleasure in furnishing you with the following information in regard to indicator tests of our compound locomotives.

The application of the indicator gear and piping to the Richmond compound locomotive is the same as that of a simple engine, viz.: A reliable reducing motion that will make the length of the card about 3″ and pipes as short as possible. It is desirable, however, to have the receiver pressure of the low pressure card and the high pressure steam chest pressure on the high pressure card in addition to the cylinder card, which is obtained by a ½″ pipe joining the indicator pipe above the three-way cock and suitable places in the respective steam chests with a cock as near the indicator connection as practicable; or even better, by a second pipe straight through the three-way cock that will reduce any swells or pockets in the passages to a minimum. Care must be taken that both the cylinder and atmospheric connections are shut off in taking the steam chest line, which is represented by one complete revolution.

The most suitable indicator springs for 170 to 190 pounds boiler pressure are 100 pounds to the inch for the high pressure cylinder, and 40 pounds for the low pressure cylinder. For from 190 to 220 pounds boiler pressure, springs 120 pounds to the inch for the high pressure and 50 pounds for the low pressure cylinder.

The valve gears are, as a rule, the same for compound and simple engines, and any difference in the work of the two cylinders may be adjusted by increasing or reducing the laps of the valves. The low pressure slide valve should not have less than ¾″ lap, and high pressure valve ⅞″ for a 6″ or 5½″ full valve travel. This proportion equalizes the work in the two cylinders very well at a cylinder ratio of 1 to 2½. At a smaller ratio the difference in laps should be increased. A good average size of laps may be considered 1$\frac{1}{16}$″ for the high pressure and $\frac{15}{16}$″ for the low pressure valve at 5½″ or 6″ valve travel respectively.

It will be found that the high pressure card, when working compound, occupies the field on the card between the boiler or valve chest pressure and that of the receiver, and the low pressure card between the receiver pressure and the atmospheric line.

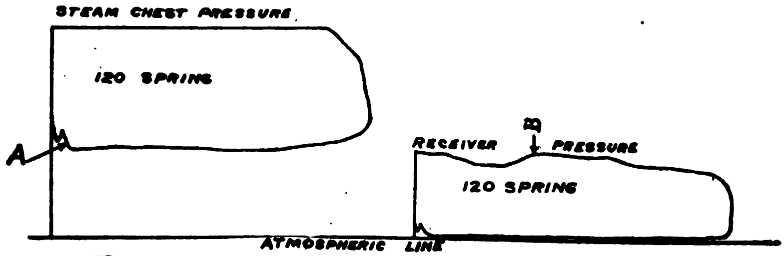



*Fig. 1* WORKING COMPOUND

Figure 1 represents a set of cards taken with springs of the same tension for both cylinders, to illustrate their relation to each other when working compound. The notch at "A" is due to the inside clearance of the valves. The hump on the low pressure card at "B" is due to the exhaust of the high pressure cylinder taking place at that moment. The wave on the bottom line of the high pressure card is caused by the variation in the receiver pressure as the low pressure cylinder takes steam or not from the receiver.

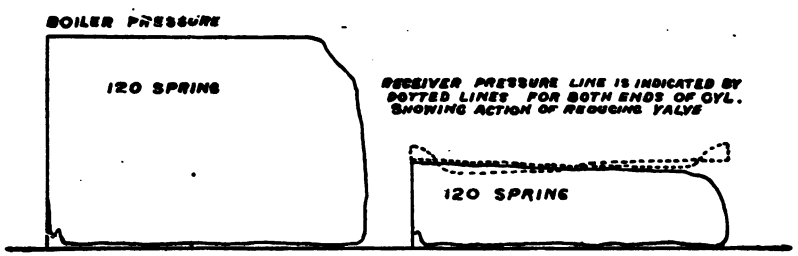



*Fig. 2* WORKING SIMPLE

Figure 2 represents a set of cards taken with springs of equal tension and working simple; that is, with the live steam in both cylinders. The effect of the reducing valve is seen on the low pressure steam chest line where the live steam is cut off at less than half the boiler pressure, and forms a double loop line on top of the cylinder diagram proper, as per dotted lines.

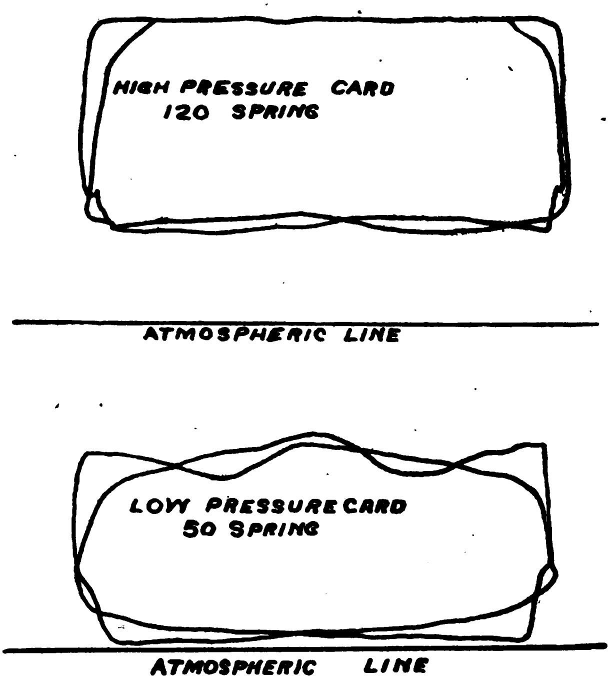



Fig. 3 CARDS TAKEN FROM ENGINE WORKING COMPOUND

Figure 3 shows a set of diagrams taken from an engine while working compound with 120 and 50 pound springs for high pressure and low pressure cylinders respectively.

In order to adjust the valves from the reading of an indicator card it is necessary that the graphic representation of the distribution of power in the engine is fairly understood and corresponding points for each end of the cylinder compared, as very often a slight shifting of the valve in the right direction may remedy defects that appear to be due to incorrect laps and other valve proportions.

In a general way, if the indicating of a simple engine is properly understood there will not be much trouble in reading the compound cards, and the operator may easily make himself familiar with the difference in the two cases.

Yours very truly,

C. J. Mellin, Chief Engineer.

## The Vauclain Four-Cylinder Compound, by the Baldwin Locomotive Works.

BALDWIN LOCOMOTVE WORKS.

Philadelphia, August 11th, 1900.

*Mr. G. W. Wildin, Chairman.*

DEAR SIR:—Replying to your letter of August 4th, to Mr. S. M. Vauclain, I attach note on the use of the indicator as applied particularly to the four cylinder compound engines.

The steam engine indicator should be applied and operated upon a four cylinder compound engine in precisely the same manner as in a single expansion engine, and the diagrams are read and interpreted in exactly the same manner. In order to bring this point out more clearly, a brief description of the valve of the four cylinder compound will be given.

The valve which is shown in Figures 1 and 2 is in effect a double "D" valve cast in one piece. The outside valve controls the admission and ex-

FIG. 1.

FIG. 2.

haust of the high pressure cylinder, the inside valve performs the same function for the low pressure cylinder.

The course of the steam during its admission, expansion and exhaust is shown by Figure 3. It will be observed that the exhaust from one end of the high pressure cylinder becomes the supply of the other end of the low pressure cylinder, and it is this particularity that makes it preferable to pipe

the indicator from one side of the high to the opposite side of the low pressure cylinder.

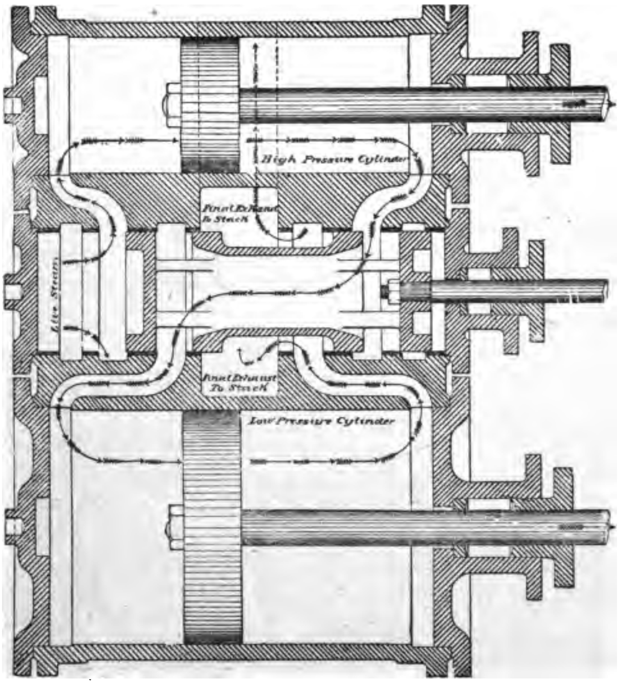
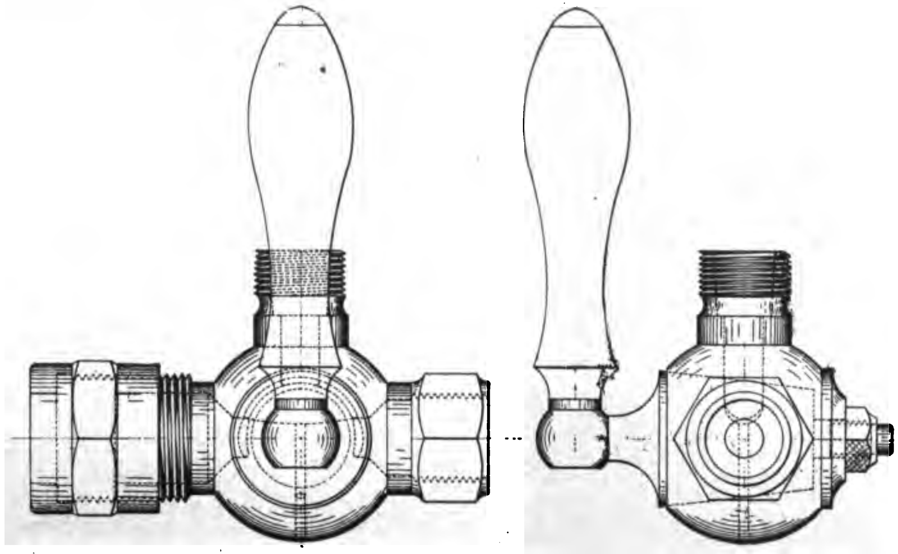



FIG. 3.

In piping cylinders of locomotives for indicating, ¾-inch pipes should be used, and they should be brought to position by bending, and should be on an incline for drainage, and they must be thoroughly lagged in order to reduce the condensation to a minimum. In four-cylinder compounds it is preferable to pipe one end of the high pressure cylinder to the opposite end of the low, interposing a three-way cock, Figure 4, to which the indicator can be directly attached. The height of the indicator pulley in line with the drive cord. It is very much easier to combine cards taken by this method, and but one correction will have to be made for any variation in the calibration of the springs. If it is desired to take diagrams from both head and crank ends of both high pressure and low pressure cylinder, two indicators will be required; for most purposes, however, one indicator will answer, and the card taken will be from the head of the high and from the crank of the low pressure cylinders, or vice versa.

The four diagrams, namely, of the high pressure head and crank and of he low pressure head and crank, can be taken with one indicator on the same card with the use of the special five way valve shown in illustration, Figure 5.

## Three Way Cock.



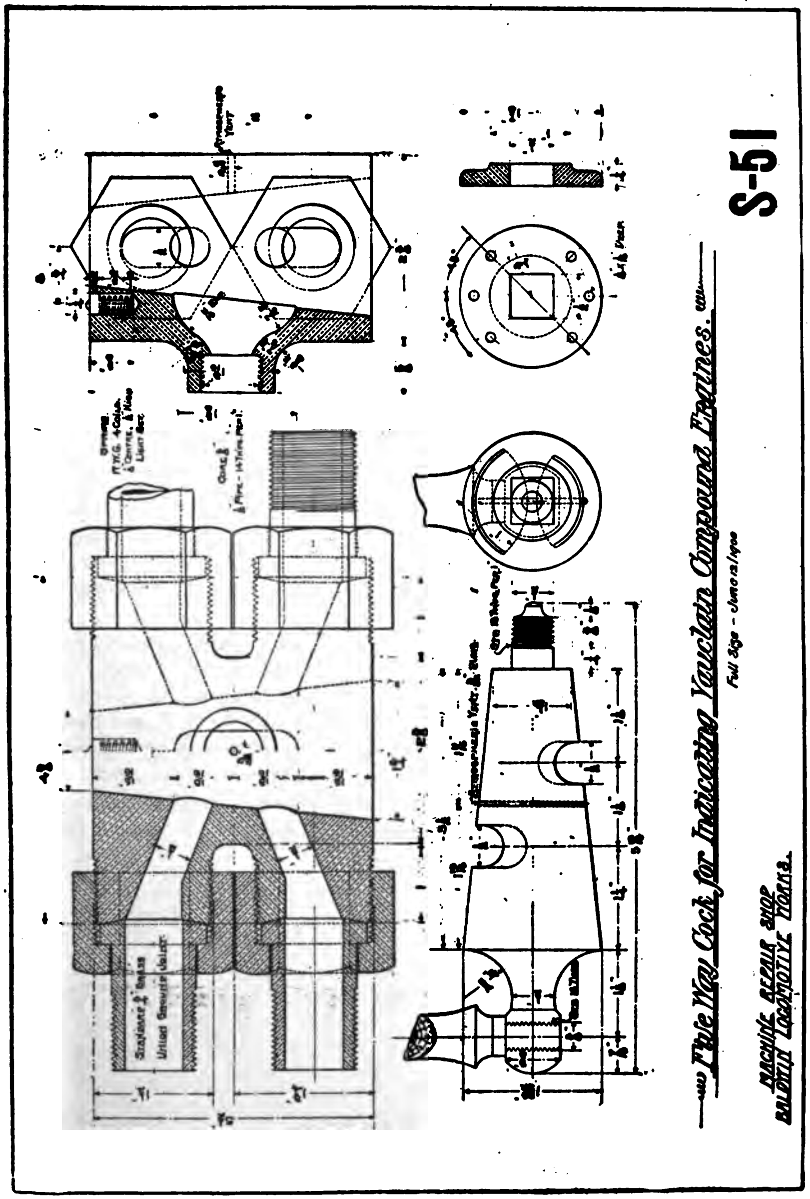

Three Way Cock for Indicating Vauclain Compound Engines.
S-51
Machine Repair Shop
Baldwin Locomotive Works.

FIG. 5.

This cock is very convenient when it is desired to test the valve motion by the use of indicators, as it saves all trouble of tracing or superimposing the indicator diagrams.

The same reducing motion can be used on compound engines as is used on single expansion engines. The pendulum reducing motion is very convenient and is used very extensively, and when the connection between the pendulum and crosshead is made by means of a horizontal link, the reduction is very nearly perfect when the rig is properly applied. The vertical link should oscillate in equal angles on both sides of the center, and should be suspended from such a point that the horizontal link will also vibrate an equal distance above and below the horizontal. This rig is very frequently applied so that the connecting link is horizontal at mid stroke; when so applied it introduces a very serious error.

Figure 6 shows a very serviceable form of reducing link.

The chief uses of the indicator can be said to be three in number:

1. To determine the power of the engine.
2. To determine its economy.
3. To determine defects in valve motion or steam passages.

The indicator diagram shows the pressure of steam in the cylinders for any position of the piston; for instance, suppose the length of an indicator diagram is three inches and the stroke of the engine is twenty-four inches, the pressure of steam after the piston has moved eight inches is shown one inch from the end of the diagram.

The average pressure of the indicator diagrams can be obtained most conveniently by getting the area by the use of any of the planimeters on the market, and dividing this area by the length of the diagram in inches. If this result is multiplied into the effective area of the piston in square inches, the average crosshead pressure is obtained which, multiplied by twice the length of stroke in feet, will give the *work* in foot-pounds per revolution. The work in foot pounds per revolution multiplied by the number of revolutions per minute gives the *power* developed per minute, which, when divided by 33,000, gives the horse power.

If P=Mean effective pressure.
L=Length of stroke in feet.
A=Area of piston, square inch.
N=Number of revolutions.
T P=Tractive power.
d=Diameter of cylinder, inches.
S=Speed in miles per hour.
D=Diameter of drivers, inches.

then

$$\frac{PLAN}{33000}=\text{H. P. and } \frac{P \times d^2 \times S}{D} = \text{T. P.}$$

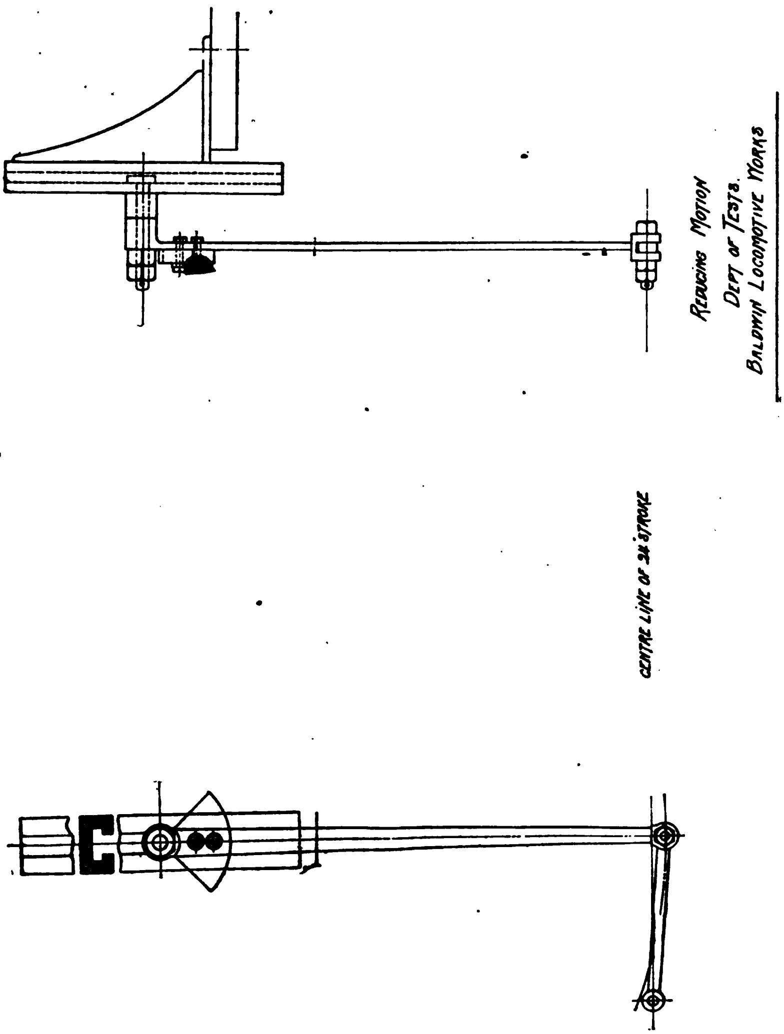

REDUCING MOTION
DEPT OF TESTS.
BALDWIN LOCOMOTIVE WORKS
CENTRE LINE OF 24 STROKE

FIG. 6.

In the case of the compound engines, each cylinder is treated separately, in the same manner as indicated above, and the results are added together.

The indicated water rate has frequently been considered the measure of an engine's economy. The actual steam consumption is, however, greater than the indicated steam consumption which does not account for water condensed in the cylinders. The method of determining the steam consumption per horse power from an indicator diagram is presented below. The method applies equally to compound and single expansion engines.

S=Stroke in inches.
C=Per cent. of stroke completed at cut-off.
Pc=Pressure of steam at cut-off, taken from zero.
Wp=Weight per cubic foot of steam at P pressure.
H=Per cent of stroke uncompleted at compression.
Q=Pressure of steam at compression, taken from zero.
Wq=Weight per cubic foot of steam at Q pressure.
E=Per cent. of clearance in H. P. cylinders.
A=Area of H. P. cylinders.
P=M. E. P. of H. P. cylinders.
a=Area of L. P. cylinders.
K=M. E. P. of L. P. cylinders.
N=Number of revolutions per minute.
r=Ratio $\frac{a}{A}$; hence, a =A x r.

The volume of the piston displacement is A. S., and the volume at cut-off is A. S. C., since C. is the proportion of stroke completed at cut-off. The volume of N revolutions would be A N S C. As there are two strokes of the piston for each revolution, and there is an engine on each side of the locomotive, assuming that both engines are doing exactly the same work, there would be four strokes per revolution; hence 4 A N S C is the volume of piston displacement at cut-off for one revolution. Since the clearance space is expressed in percentage of the piston displacement of one stroke, and this space is filled at each stroke, the volume of the clearance space for one revolution would be 4 A N S E. The sum of these two quantities divided by 1728 will give the volume in cubic feet. The indicator-card gives the pressure at cut-off, and a reference to the steam table will give the weight of steam at that pressure; hence, the amount of steam used per revolution becomes

$$\frac{(4\,A\,N\,S\,C + 4\,A\,N\,S\,E)}{1728}\,Wp.$$

But there is a certain amount of steam saved at compression, and the volume at this point would be

$$\frac{(4\,A\,N\,S\,H + 4\,A\,N\,S\,E)}{1728}\,Wq.$$

The volume of the clearance space being again taken into consideration,

since this steam is saved by compression, it should be deducted from the amount used, and the formula becomes:

$$\frac{(A\,N\,S\,C + 4\,A\,N\,S\,E)}{1728}\,Wp. - \frac{(4\,A\,N\,S\,H + 4\,A\,N\,S\,E)}{1728}\,Wq\text{; or}$$

$$\frac{4\,A\,N\,S}{1728}\left\{ (C+E)\ Wp - (H+E)\,Wq \right\}$$ The H. P. equals

$$\frac{4\,A\,N\,S\,(P+r\,K)}{12x33000}$$

Then the water rate per minute would be

$$\frac{\dfrac{4\,A\,N\,S}{1728}\left\{ (C+E)\,Wp - (H+E)\,Wq \right\}}{\dfrac{4\,A\,N\,S\,(P+r\,K)}{12x33000}} \text{ or}$$

$$\frac{229.16}{P+r\,K}\left\{ (C+E)\,Wp - (H+E)\,Wq \right\}$$

and the rate per hour would be

$$\frac{60x229.16}{P+r\,K} \text{ or } \frac{13750}{P+r\,K}\left\{ (C+E)\,Wp - (H+E)\,Wq, \right.$$

the formula of the most convenient form to use.

If it is desired to get the steam at releast H-P., substitute the values of the point R and pressure t, also S x R, respectively, for C, P and C x S. See Figures 7 and 8.

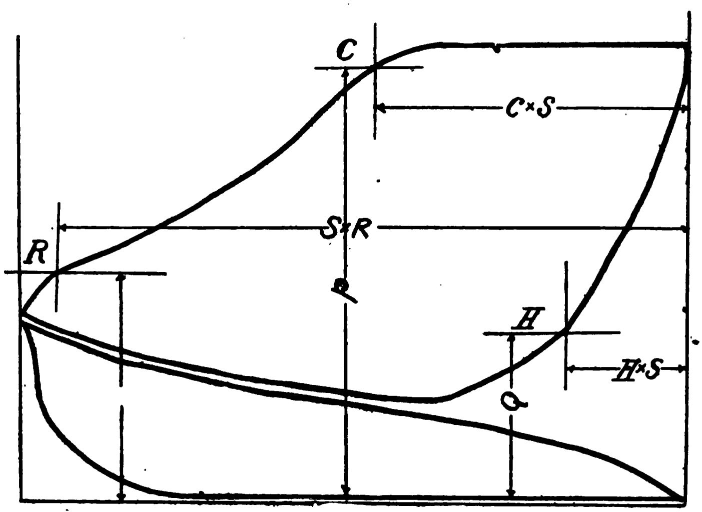



FIG. 7.

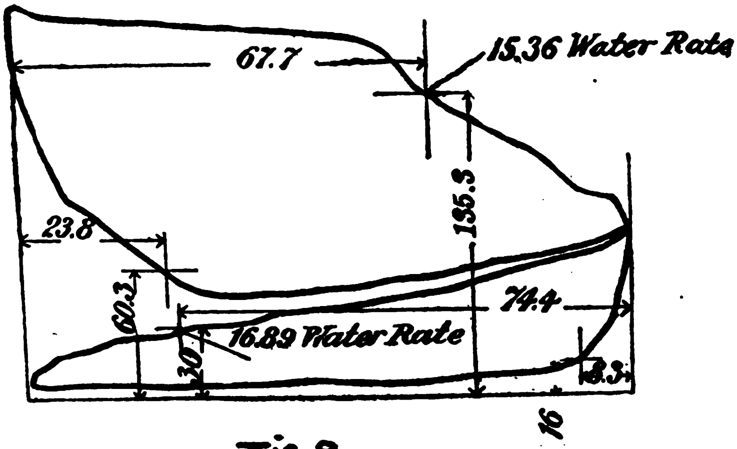



Fig 8

M. E. P. H. P. cylinder .......... 87 pounds, Clearance .08
M. E. P. L. P. cylinder........... 32 pounds, Ratio 2.87 to 1
M. E. P. referred to H. P. cylinder.................. 178.84
M. E. P. referred to L. P. cylinder................... 62.31

$$178.84 = P + r\,K$$

$$62.31 = K + \frac{P}{r}$$

$$\frac{\begin{matrix}135.3\\14.7\end{matrix}}{150.0} = .3375$$ pound per cubic foot of steam at cut-off H. P. cylinder.

$$\frac{\begin{matrix}60.3\\14.7\end{matrix}}{75.0} = .1756$$ pound per cubic foot of steam at compression H. P. cyl.

$$\frac{\begin{matrix}30\\14.7\end{matrix}}{44.7} = .1079$$ pound per cubic foot of steam at point on L. P. expansion line.

$$\frac{\begin{matrix}8.\\16.\\14.7\end{matrix}}{30.7} = .0758$$ pound per cubic foot of steam at compression L. P. cylinder.

$$\frac{13750}{178.84} = 76.88 \qquad \frac{13750}{62.31} = 220.67$$

(.677 + .08) x .3376 = .2556 (.238 + .08) x 1756 = .0558

.2556

.0558

.1998

.1998 x 76 88 = 15.36 pounds steam at cut-off H. P. cylinder.

(.744 + .08) x .1079 = .0889 (.083 + .08) x .0758 = .0124

.0889

.0124

.0765

.0765 x 220.67 = 16.89 pounds steam at point on expansion line L. P. cyl.

The following method of combining indicator diagrams, devised by Mr. George H. Barrus, is given also, and is generally accepted by all engineers as the correct method.

## METHOD OF COMBINING CARDS.

The method employed corresponds to that given in Rankine's book on the steam engine, but is here given more in detail. This method will be clearly understood if it is remembered that every point in the expansion line of the L. P. card of the combined diagram, should correctly represent the pressure and volume of steam at the corresponding point of the stroke of the low-pressure piston, the volume being measured from the clearance line of that cylinder. Referring to Figure 9, the H. P. diagram is an exact copy of the original except in point of scale. The L. P. diagram at the bottom of Figure 9 is also an exact copy of the original on the same scale of pressure as the H. P. diagram, though of different length; this last having the same ratio to the length of the H. P. diagram as the area of the piston of the L. P. cylinder has to the area of that of the high; in this case 2.9. The length of the H. P. diagram on the scale of the chart is 100, as indicated, and of the L. P. diagram 290.

To draw the L. P. portion of the diagram, it may be divided into, say ten equal parts, and the points of the division marked a–b–c–d–and–e. The various points on the combined L. P. diagram are located horizontally, so as to mark the various volumes occupied by the steam at the respective points, as already noted. Below the point of cut-off which is located at .6 of the stroke, or at the point 9, the combined diagram is an exact reproduction of the lower diagram. The points in this portion of the diagram showing volume, that is, the horizontal distances, represent the volumes of the L. P. cylinders at those points, plus the clearance of the same. The clearance is 6.5 per cent. of the stroke of the L. P. piston, or is 18.9 points of division on the scale of the chart. The distance, for example, of the point "h" from the clearance line on the combined diagram will be .7 of 290+19, or 203+19= 222, and likewise for the remaining points below the cut-off. The points in the expansion line of the L. P. combined diagram, above the points of cut-off, lie farther to the left, for the reason that the volume of the steam ex-

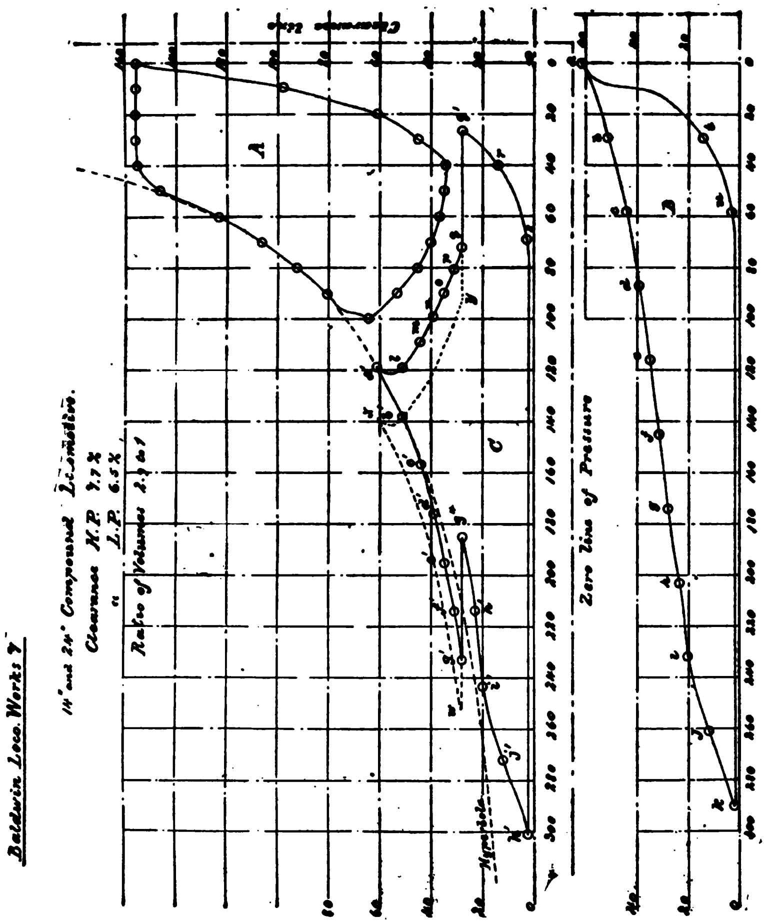

Baldwin Loco. Works
14" and 24" Compound Locomotive
Clearance H.P.
L.P.
Ratio of Volumes
Zero line of Pressure
Hyperbola
Clearance Line

FIG. 9.

panding is not only the apparent volume of that contained in the L. P. cylinder, but in addition that of the steam being exhausted from the H. P cylinder (the valve being open between the two), and that contained in the clearance space of the same. Take, for instance, the point a', or the initial point of the diagram ; the volume here is that of the H. P. cylinder, the clearance of the H. P. cylinder, and the clearance of the L. P. cylinder. The point a' is therefore laid off at a distance of 19 divisions to the left of the end of the H. P. diagram, or at the division marked 119 on the chart. At the point b' the volume of the steam has been increased, corresponding to 1-10 of the L. P. cylinder, or 29 divisions, but at the same time it has been reduced correspondingly to 1-10 of the H. P. cylinder, or to 10 divisions, so that the combined effect is to increase the volume 19 divisions to the left of the point a' the remaining points from b' to g' are laid off successfully at distances of 19 divisions. At g', where the valve closes and cuts off communications between the H. P. and L. P. cylinders, the volume contracts, and this feature is represented by the horizontal line g' g". To obtain the remaining points of the combined diagram from a' to q', the various points are laid off so that the horizontal distances from the expansion line shall be the same as those in the lower diagram.

In this way the area of the combined diagram is exactly the same as that of the original diagram. The dotted line x w y shows the position of the combined diagram, supposing the intermediate space within the valve were empty when the H. P. cylinder exhausted, assuming that the volume of this space is 20 per cent. of the volume of the H. P. In reality this space is not empty, but is always filled with steam somewhat above the pressure at cut-off in L. P. cylinders.

Defects in valve motion are very frequently masked by the wire drawing of steam, but if the valves are square, there should be very little difference between simultaneously taken cards of the head and crank ends when such cards are superimposed. If the valve and ports are symmetrical, and if one end has a longer cut-off combined with an earlier compression, there is spring in the valve gear or the lost motion is taken up all in one direction, or the valve stem is too long or too short, depending upon which end of the stroke gives the longer cut-off. The sloping of the admission line towards the expansion line is an indication of lost motion in valve gear, poor lubrication of the valve or insufficient lead, that is late opening of the valve. The sloping of the admission line away from the expansion line or a sharp horizontal projection in the upper corner of the indicator diagram is an indication of excessive lead. The effect of excessive compression is shown by a large loop at the corner of the indicator diagram. This effect is also produced by excessively small clearance spaces. A fall in the steam lines indicates insufficient port opening or too small steam passages; a high back pressure line shows the insufficient exhaust port opening or contracted exhaust passages.

We have no diagram illustrating these defects, but Figure 10 shows a few typical diagrams taken from four cylinder compound engines.

Respectfully, H. V. WILLE.

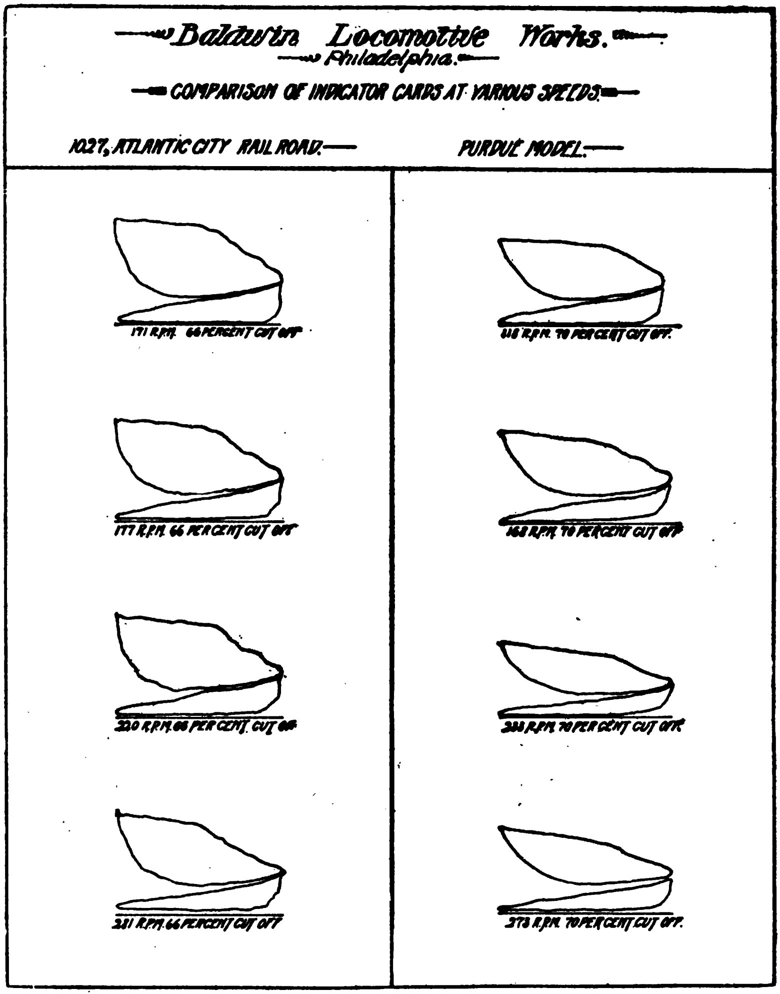

Baldwin Locomotive Works.
Philadelphia.
COMPARISON OF INDICATOR CARDS AT VARIOUS SPEEDS.
1027, ATLANTIC CITY RAIL ROAD.
PURDUE MODEL.
171 R.P.M. 66 PER CENT CUT OFF
177 R.P.M. 66 PER CENT CUT OFF
220 R.P.M. 66 PER CENT. CUT OFF
231 R.P.M. 66 PER CENT CUT OFF
373 R.P.M. 70 PER CENT CUT OFF.

FIG. 10.

## RECOMMENDATIONS.

Your committee offers the following recommendations and suggestions, in connection with the indicator and its uses by members of this Association:

### THE INDICATOR.

The selection of the style and make of the instrument is referred to the taste and judgment of the one who pays the money for it. Some suggestions as to meritorious features of any make of instrument will not be amiss, however. The lightness of the moving parts is a redeeming feature, as inertia at high speeds is annoying. All manufacturers strive to make their instruments perfect, but occasionally instruments pass out upon the market with the piston too snugly fitted in the cylinder or the different joints adjusted somewhat tighter than they ought to be. These defects, though apparently small, will cause a defective card to be taken which will manifest its ailments in the form of serrated or notched lines, which renders the card useless as far as any information concerning the engine is concerned.

For full information as to make, care and merits of the best makes of instruments, you are referred to Part IV. of this paper. Your committee does not feel that it can add very much to the suggestions made by the manufacturers themselves.

### THE INDICATOR SPRING.

In selecting a suitable spring for the work to be done, the governing features are speed and boiler pressure.

We recommend that an 80 spring be used with boiler pressures of 150 pounds or less, and at speeds, the maximum not to exceed 50 miles per hour. For boiler pressures of 150 to 200 pounds, and at any speed up to 75 miles per hour, a spring of 100 should be used. For pressures of 200 to 225 pounds a spring of 120 should be used.

In general the lightest spring possible which will produce a smooth outline on the card without making its maximum height over 2 inches should be used.

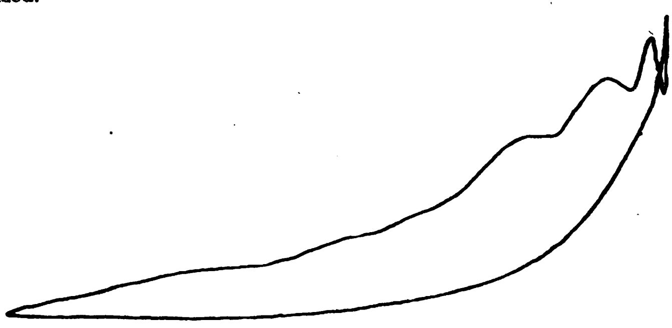


Fig. 10

The effect upon the outline of the card due to an under-strength spring is illustrated in Figure 10.

| | |
|---|---|
| Scale of spring | 80 |
| Miles per hour | 70 |
| Boiler pressure | 170 |

THE PIPING.

For piping an engine we prefer a ¾-inch pipe to that of ½-inch. The length of the pipes will, of course, be controlled by the construction of the engine. We recommend that the length and style of piping approach that shown in Plate XV. as nearly as possible. The majority of engines are possibly so constructed that this arrangement cannot be duplicated, but we are convinced that long pipes are often used where short ones could be substituted, were the operator willing to exert himself a little in taking the cards. The connection of the pipes to the cylinder should be made by bends instead of elbows, and the bends should be as easy as possible. No white lead or any other pasty material should be used in making the joint. If anything is used it should be a clean oil, and the pipes should be thoroughly blown out by steam before the indicator is attached. If the pipes are of a considerable length they should be covered by some good non-conductor of heat. It should be known that the holes in the cylinder are not at all covered by the piston at the end of the stroke. If necessary, the cylinder head projection should be chipped in order to get a full size opening to the cylinder from the indicator pipe.

THE THREE-WAY COCK.

A three-way cock and a single instrument are preferable to a two-way cock and an instrument at each end of the cylinder.

The three-way cock should have a good ground joint, and watch should be kept to see that no leak occurs. If a leak occurs in [the three-way cock, the atmospheric lines will not, of course, be where they ought to be.

STEAM CHEST CARD.

In general, we would not recommend the taking of a steam chest card unless the cards taken from the cylinder show a defect which would appear to indicate a lack of free passage of steam from the boiler to the steam chest when the throttle is wide open. In such a case we would advocate the application of the indicator to the steam chest, and would use a four-way cock if an extra instrument were not at hand.

THE OPERATOR'S BOX.

The points to be sought in constructing a place for the operator to use are : First, strength; second, cheapness; third, the protection of the operator from the currents of the air, and fourth, no part of the box should be below the cylinder head casing. This will prevent any injury to the operator should a cylinder head be knocked out accidentally.

### THE REDUCING MOTION.

There is but one essential thing required of reducing motions, and any mechanism which does not meet this one requirement is worthless and should be discarded. The feature referred to is that the movement of the indicator drum must correspond accurately with the movement of the piston. Part IV. of this report contains the cuts and description of many patented devices, most all of which take the form of reducing wheels. They have their good and their bad points.

Another class of reducing motions which work upon the principle of the lever are in common use. The test for any mechanism of this class for accuracy is whether or not the fulcrum, the point at which the indicator cord is attached, and the point of attachment to the cross-head, remain at all times in one and the same straight line. If they do they are all right; if not they are worthless.

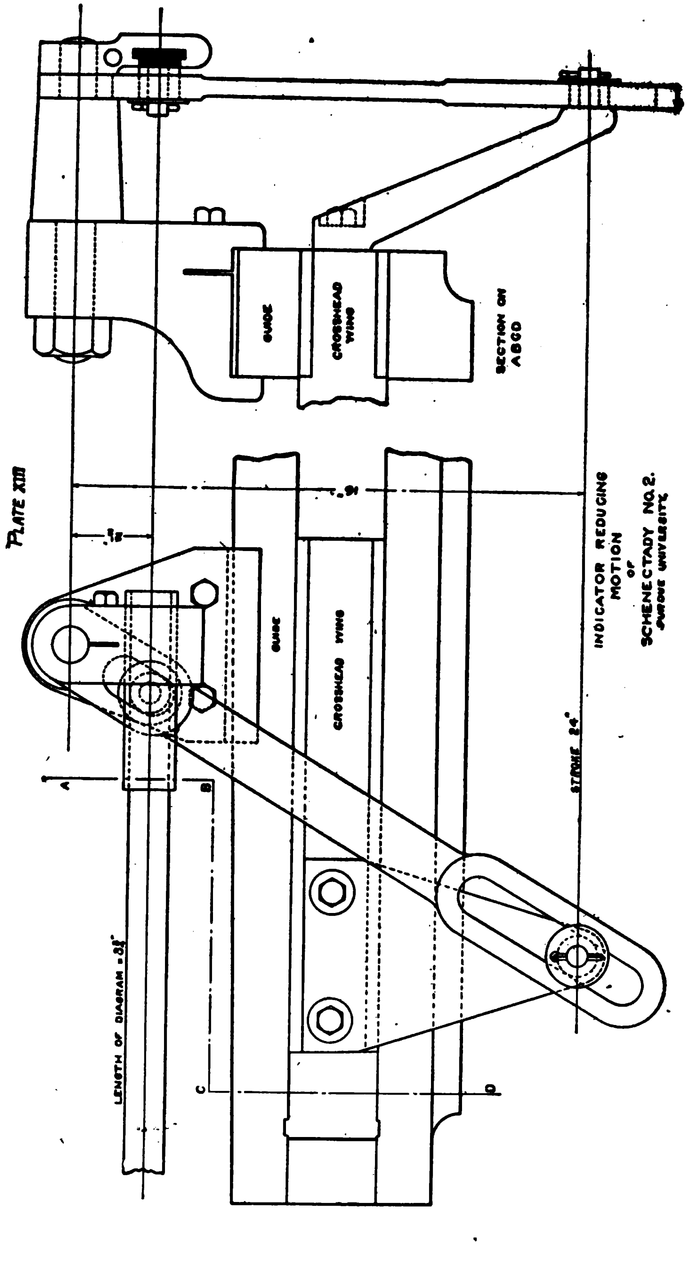
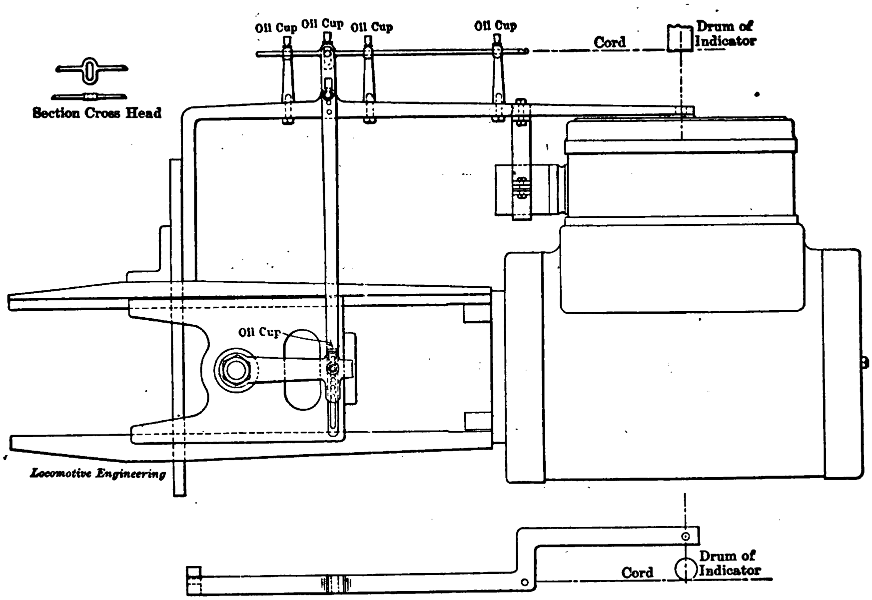


PLATE XIII
INDICATOR REDUCING
MOTION
OF
SCHENECTADY NO. 2.
PURDUE UNIVERSITY
SECTION ON
ABCD
GUIDE
CROSSHEAD
WING
GUIDE
CROSSHEAD WING
STROKE 24"
A
B
C
D

# PLATE XIV.


Oil Cup
Oil Cup
Oil Cup
Oil Cup
Cord
Drum of Indicator
Section Cross Head
Oil Cup
Locomotive Engineering
Cord
Drum of Indicator

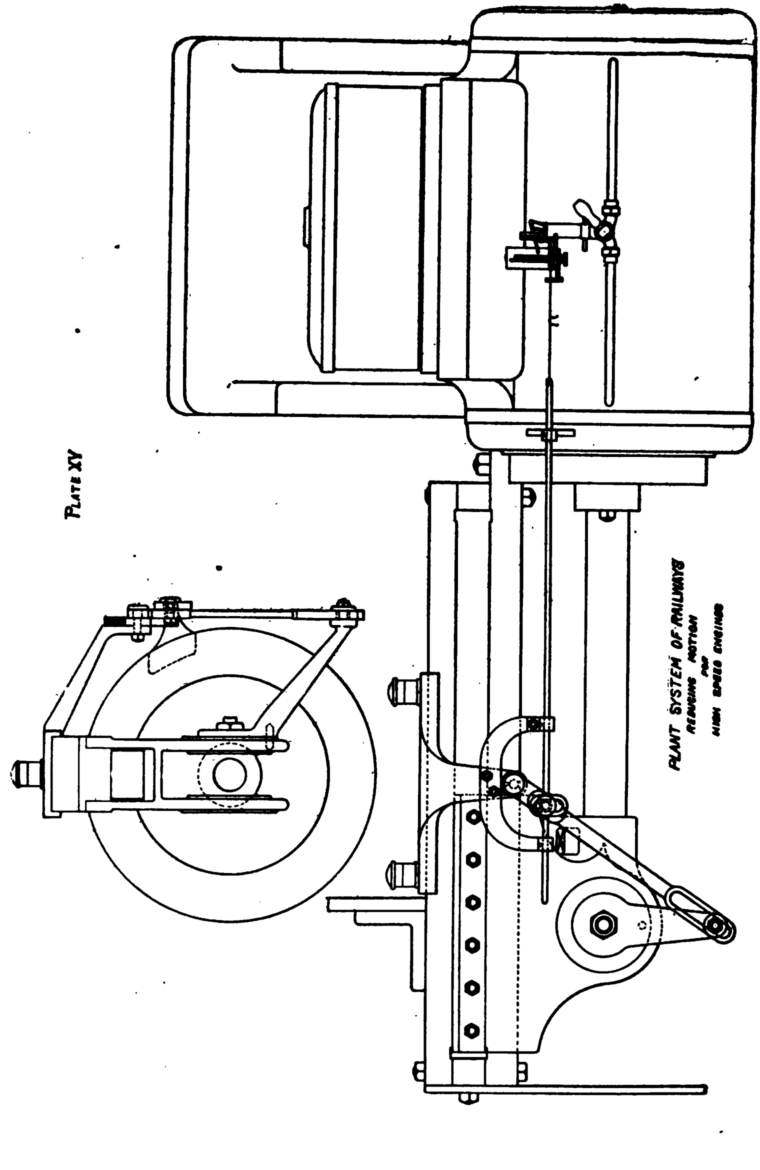


PLATE XV

PLANT SYSTEM OF RAILWAYS
REDUCING MOTION
FOR
HIGH SPEED ENGINES

Plate XIII. is the style of reducing motion used by the Purdue University in making tests on their testing plants. It is very simple and durable, as well as accurate. Plate XIV. is a form used by the Plant System of Railways for slow speed engines, or where the object is for valve adjustment only. The same road uses for high speed engines a modified form of Plate XIV., which is shown in Plate XV. This latter design differs but slightly from the form used by Purdue University. The advantages of the three forms shown consist in the certainty of getting a positive motion, combined with a very short cord which can be attached or detached at will, regardless of the speed.

The old "Brumbo" pulley is familiar to all and needs no illustrating here. While it is necessary to use considerable length of string with this motion, its cheapness and ease of construction, combined with its range of adaptability, makes it a favorite, and for all ordinary purposes is good enough.

### WHEN TO INDICATE AN ENGINE.

It is the opinion of your committee that the majority of engines are indicated at the wrong time.

Most all motive power men apply the indicator to new engines, or old engines newly overhauled, to show how nice they work. This is a mistake. Unless it be for the purpose of valve adjustment, there can be but little gained by applying the indicator to good working engines. We believe that the only absolutely certain method of adjusting valves for any given service is by means of the indicator, and would recommend that this practice be followed systematically by the men who have charge of this department of the work. The time to apply the indicator to an engine is when it fails to do the work it ought to do, or when it fails to do the work other engines of the same class are doing daily. This is the time, we think, when by applying the indicator the railroad company would get splendid returns for the expense incurred. We ought to find out the weak points of our engines and rectify them, rather than spend time and money working up information to show how nice the good ones work.

### THE FORCE REQUIRED TO DO THE WORK.

We would recommend that the Traveling Engineer and an assistant be given charge of this work. The assistant should be either an apprentice from the machine shop or some good, bright fireman. We would recommend the fireman if he can be had. Our firemen of to-day are to be our engineers of the future, and no fireman can accompany the Traveling Engineer during these test trips without becoming himself interested in the work. This interest, once excited in him, will lead him to thoroughly investigate valve motion and its effect upon steam distribution, and certainly any knowledge gained concerning the lungs of the locomotive will not detract from his worth as an engineer. If the valves are to be adjusted while on the road, a machinist should be taken instead of the fireman.

### WHAT TO LOOK FOR IN TAKING CARDS.

Many things might suggest themselves in doing indicator work which would be interesting and very gratifying to the investigative mind, but would be of little practical utility to either the Traveling Engineer or the company he represents. We believe the following salient points, if properly looked after, will pay for the trouble of investigation.

The proper amount of lead for the service the engine is called upon to perform. There can be enough lead, there can be too much lead, and there can be too little lead. The happy medium is what we want, and the indicator card will show what we have. A leaky valve, which will make our card appear abnormal; a leaky packing ring, which will increase our back pressure and decrease our M. E. P.; The back pressure and compression lines of a card taken with the engine at working speed; the squareness of the valve, etc. The horse power is, of course, to be calculated from the cards, and many other things may be learned from a close study of the cards taken. The Traveling Engineer should make himself so familiar with the cards and the influences which produced them that he will not attempt to get by adjustment what must be had by design.

### DATA TO BE TAKEN.

We would recommend that a small book which can be carried in the coat pocket be selected and ruled in a convenient form for recording the necessary data.

The following form, we believe, will be found convenient and sufficient:

*A., B. & C. Railroad.*

LONDON,............................1900.

Indicator cards taken from engine No......................; cylinders ........"x........"; driving wheels..........";  hauling train No........; between............and............; distance............

Weight of engine and tender ...............................

Weight of train........................................

Coal used.........................................tons

Water used.....................................gallons

| Card No. | Speed in miles per hour. | Boiler Pressure. | Cut-off. | Position of throttle. | Scale of spring. | Remarks. |
|---|---|---|---|---|---|---|
| | | | | | | NOTE — Any information may be added here, such as time of arrival and departure, delays, etc. Mile post cards were taken at, and anything out of the ordinary. |

From the foregoing records we believe all the calculations can be made which will be of any real benefit to the company and are such as require but little effort to secure. But one test should be recorded on a page, and the book, when full, should be filed as a permanent record.

### CONTINUATION OF THE SUBJECT.

We believe it would be the proper move for the Association to make to appoint from year to year a new committee to make investigations and present to the Association all new facts as they may find them, and prove those already presented and suggested. The subject is of great importance to this Association, and it should be kept in mind at all times.

# PART III.

## DEFINITIONS, TABLES AND FORMULAE.

### CLOSSARY OF TERMS.

*Unit of Work*—Is equal in amount to the power required to lift one pound, one foot high, and is called the Foot Pound.

*A Horse Power* (*H. P.*)—Is 33,000 pounds lifted to a height of one foot in one minute of time, or equivalent motion against resistance.

*Indicated Horse Power* (*I. H. P.*)—Is the horse power of an engine as computed from the Indicator Diagram. If the mean area of the piston be multiplied by the mean effective pressure exerted against it, and also by its speed in feet per minute, this product, on being divided by 33,000, will be the indicated horse power of the engine.

*Net Horse Power*—Is the indicated horse power of an engine less the horse power which is consumed in overcoming its own resistance.

*Boiler Pressure*—Is the pressure above atmosphere, or the pressure as shown by a correct steam guage.

*Absolute Pressure*—Of steam is its pressure reckoned from vacuum: the pressure as shown by an ordinary steam gauge, plus the pressure of the atmosphere, which is 14.7 pounds per square inch.

*Initial Pressure*—Is the pressure in the cylinder as shown by the indicator, at the beginning of the stroke. The initial pressure is usually below the gauge pressure, on account of the wire drawing through the passages between the cylinder and the boiler.

*Terminal Pressure*—Is the pressure that would be in the cylinder at the end of the stroke, if the exhaust-valve did not open until the stroke was completed. It may be found by extending the expansion curve to the end of the diagram. The theoretical terminal pressure is found by dividing the pressure at cut-off by the ratio of the expansion.

*Mean Effective Pressure* (*M. E. P.*)—Is the average of the pressures recorded by the indicator at different points of the stroke above the exhaust or back pressure. It is the pressure which would have to act upon the piston throughout the entire stroke to enable the engine to develop the same power as under the indicated conditions.

*Back Pressure*—Or counter pressure, is the amount of pressure above the atmospheric line during the exhaust stroke. The back pressure counteracts the forward movement of the piston, and, therefore, should be avoided. On an indicator diagram it is found by allowing the instrument to trace the atmospheric line after tracing the diagram.

*Compression*—Is the result caused by the action of the piston in compressing into the clearance space the steam remaining in the cylinder after the exhaust valve closes.

*Wire-Drawing*—Is the operation, accidental or intentional, of reducing the pressure of steam between the boiler and cylinder, by causing it to pass through restricted passages. Wire-drawing generally, but not always, brings about initial expansion.

*Initial Expansion*—Is the fall of pressure along the steam line of the diagram, which often takes place in an engine cylinder, between the points of initial pressure and cut-off.

*Ratio of Expansion*—Is the entire cylinder volume, divided by the volume at cut-off.

*Piston Displacement*—Is the stroke of the piston in inches multiplied by the area of the piston in square inches. The product is the displacement in cubic inches.

*Clearance*—Is all the space or waste room between the piston at the end of its stroke and the face of the valve. Its volume or amount is usually expressed in its percentage of the piston displacement.

*Saturated or Dry Steam*—Is steam in perfect gaseous state. Any loss of heat will change its condition by partial condensation.

*Superheated Steam*—Is such as is heated above the temperature of saturation.

*The Diagram*—Is the outline traced by the pencil upon a card or paper, and a piece of paper becomes an indicator card when it is used to record one or more diagrams. A card often contains a diagram from both ends of the cylinder.

*The Indicator*—Is an instrument for recording pressures. When attached to a locomotive cylinder, and communication opened between the two, it records the pressure at every point in the stroke for one complete revolution.

# Circumferences and Areas of Circles.

| Diam. | Circ. | Area. | Diam. | Circ. | Area. | Diam. | Circ. | Area. |
|---|---|---|---|---|---|---|---|---|
| 1-32 | .0981 | .00076 | 5½ | 17.27 | 23.758 | 12 | 37.69 | 113.09 |
| 1-16 | .1963 | .00306 | | 17.67 | 24.850 | | 38.09 | 115.46 |
| 1-8 | .3926 | .01227 | 5¾ | 18.06 | 25.967 | 12¼ | 38.48 | 117.85 |
| 3-16 | .5890 | .02761 | | 18.45 | 27.108 | | 38.87 | 120.27 |
| 1-4 | .7854 | .04908 | 6 | 18.84 | 28.274 | 12½ | 39.27 | 122.71 |
| 5-16 | .9817 | .07669 | | 19.24 | 29.464 | | 39.66 | 125.18 |
| 3-8 | 1.178 | .1104 | 6¼ | 19.63 | 30.679 | 12¾ | 40.05 | 127.67 |
| 7-16 | 1.374 | .1503 | | 20.02 | 31.919 | | 40.44 | 130.19 |
| 1-2 | 1.570 | .1963 | 6½ | 20.42 | 33.183 | 13 | 40.84 | 132.73 |
| 9-16 | 1.767 | .2485 | | 20.81 | 34.471 | | 41.23 | 135.29 |
| 5-8 | 1.963 | .3097 | 6¾ | 21.20 | 35.784 | 13¼ | 41.62 | 137.88 |
| 11-16 | 2.159 | .3712 | | 21.57 | 37.122 | | 42.01 | 140.50 |
| 3-4 | 2.356 | .4417 | 7 | 21.99 | 38.484 | 13½ | 42.41 | 143.13 |
| 13-16 | 2.553 | .5184 | | 22.38 | 39.871 | | 42.80 | 145.80 |
| 7-8 | 2.748 | .6013 | 7¼ | 22.77 | 41.282 | 13¾ | 43.19 | 148.48 |
| 15-16 | 2.945 | .6902 | | 23.16 | 42.718 | | 43.58 | 151.20 |
| 1 | 3.141 | .7854 | 7½ | 23.56 | 44.178 | 14 | 43.98 | 153.93 |
| | 3.534 | .9940 | | 23.95 | 45.663 | | 44.37 | 156.69 |
| 1¼ | 3.927 | 1.227 | 7¾ | 24.34 | 47.173 | 14¼ | 44.76 | 159.48 |
| | 4.319 | 1.484 | | 24.74 | 48.707 | | 45.16 | 162.29 |
| 1½ | 4.712 | 1.767 | 8 | 25.13 | 50.265 | 14½ | 45.55 | 165.13 |
| | 5.105 | 2.073 | | 25.52 | 51.848 | | 45.94 | 167.98 |
| 1¾ | 5.497 | 2.405 | 8¼ | 25.91 | 53.456 | 14¾ | 46.33 | 170.87 |
| | 5.890 | 2.761 | | 26.31 | 55.088 | | 46.73 | 173.78 |
| 2 | 6.283 | 3.141 | 8½ | 26.70 | 56.745 | 15 | 47.12 | 176.71 |
| | 6.675 | 3.546 | | 27.09 | 58.426 | | 47.51 | 179.67 |
| 2¼ | 7.068 | 3.976 | 8¾ | 27.48 | 60.132 | 15¼ | 47.90 | 182.65 |
| | 7.461 | 4.430 | | 27.88 | 61.862 | | 48.30 | 185.66 |
| 2½ | 7.854 | 4.908 | 9 | 28.27 | 63.617 | 15½ | 48.69 | 188.69 |
| | 8.246 | 5.411 | | 28.66 | 65.396 | | 49.08 | 191.74 |
| 2¾ | 8.639 | 5.939 | 9¼ | 29.05 | 67.200 | 15¾ | 49.48 | 194.82 |
| | 9.032 | 6.491 | | 29.45 | 69.029 | | 49.87 | 197.93 |
| 3 | 9.424 | 7.068 | 9½ | 29.84 | 70.882 | 16 | 50.26 | 201.06 |
| | 9.817 | 7.669 | | 30.23 | 72.759 | | 50.65 | 204.21 |
| 3¼ | 10.21 | 8.295 | 9¾ | 30.63 | 74.662 | 16¼ | 51.05 | 207.39 |
| | 10.60 | 8.946 | | 31.02 | 76.588 | | 51.44 | 210.59 |
| 3½ | 10.99 | 9.621 | 10 | 31.41 | 78.539 | 16½ | 51.83 | 213.82 |
| | 11.38 | 10.320 | | 31.80 | 80.515 | | 52.22 | 217.07 |
| 3¾ | 11.78 | 11.044 | 10¼ | 32.20 | 82.516 | 16¾ | 52.62 | 220.35 |
| | 12.17 | 11.793 | | 32.59 | 84.540 | | 53.01 | 223.65 |
| 4 | 12.56 | 12.566 | 10½ | 32.98 | 86.590 | 17 | 53.40 | 226.98 |
| | 12.95 | 13.364 | | 33.37 | 88.664 | | 53.79 | 230.33 |
| 4¼ | 13.35 | 14.186 | 10¾ | 33.77 | 90.762 | 17¼ | 54.19 | 233.70 |
| | 13.74 | 15.033 | | 34.16 | 92.885 | | 54.58 | 237.10 |
| 4½ | 14.13 | 15.904 | 11 | 34.55 | 95.033 | 17½ | 54.97 | 240.52 |
| | 14.52 | 16.800 | | 34.95 | 97.205 | | 55.37 | 243.97 |
| 4¾ | 14.92 | 17.720 | 11¼ | 35.34 | 99.402 | 17¾ | 55.76 | 247.45 |
| | 15.31 | 18.665 | | 35.73 | 101.62 | | 56.16 | 250.94 |
| 5 | 15.70 | 19.635 | 11½ | 36.12 | 103.86 | 18 | 56.54 | 254.46 |
| | 16.10 | 20.629 | | 36.52 | 106.13 | | 56.94 | 258.01 |
| 5¼ | 16.49 | 21.647 | 11¾ | 36.91 | 108.43 | 18¼ | 57.33 | 261.58 |
| | 16.88 | 22.690 | | 37.30 | 110.75 | | 57.72 | 265.18 |

## Circumferences and Areas of Circles.—Continued.

| Diam. | Circ. | Area. | Diam. | Circ. | Area. | Diam. | Circ | Area. |
|---|---|---|---|---|---|---|---|---|
| 18½ | 58.11 | 268.80 | 25½ | 80.10 | 510.70 | 32½ | 102.1 | 829.57 |
| | 58.51 | 272.44 | | 80.50 | 515.72 | | 102.4 | 835.97 |
| 18¾ | 58.90 | 276.11 | 25¾ | 80.89 | 520.70 | 32¾ | 102.8 | 842.39 |
| | 59.29 | 279.81 | | 81.28 | 525.83 | | 103.2 | 848.83 |
| 19 | 59.69 | 283.52 | 26 | 81.68 | 530.93 | 33 | 103.6 | 855.30 |
| | 60.08 | 287.27 | | 82.07 | 536.04 | | 104.0 | 861.79 |
| 19¼ | 60.47 | 291.03 | 26¼ | 82.46 | 541.18 | 33¼ | 104.4 | 868.30 |
| | 60.86 | 294.83 | | 82.85 | 546.35 | | 104.8 | 874.88 |
| 19½ | 61.26 | 298.64 | 26½ | 83.25 | 551.54 | 33½ | 105.2 | 881.41 |
| | 61.65 | 302.48 | | 83.64 | 556.76 | | 105.6 | 888.00 |
| 19¾ | 62.04 | 306.35 | 26¾ | 84.03 | 562.00 | 33¾ | 106.0 | 894.61 |
| | 62.43 | 310.24 | | 84.43 | 567.26 | | 106.4 | 901.25 |
| 20 | 62.83 | 314.16 | 27 | 84.82 | 572.55 | 34 | 106.8 | 907.92 |
| | 63.22 | 318.09 | | 85.21 | 577.87 | | 107.2 | 914.61 |
| 20¼ | 63.61 | 322.06 | 27¼ | 85.60 | 583.20 | 34¼ | 107.5 | 921.32 |
| | 64.01 | 326.05 | | 86.00 | 588.57 | | 107.9 | 928.06 |
| 20½ | 64.40 | 330.06 | 27½ | 86.39 | 593.95 | 34½ | 108.3 | 934.82 |
| | 64.79 | 334.10 | | 86.78 | 599.37 | | 108.7 | 941.60 |
| 20¾ | 65.18 | 338.16 | 27¾ | 87.17 | 604.80 | 34¾ | 109.1 | 948.41 |
| | 65.58 | 342.25 | | 87.57 | 610.26 | | 109.5 | 955.25 |
| 21 | 65.97 | 346.36 | 28 | 87.96 | 615.75 | 35 | 109.9 | 962.11 |
| | 66.36 | 350.49 | | 88.35 | 621.26 | | 110.3 | 968.99 |
| 21¼ | 66.75 | 354.65 | 28¼ | 88.75 | 626.79 | 35¼ | 110.7 | 975.90 |
| | 67.15 | 358.84 | | 89.14 | 632.35 | | 111.1 | 982.84 |
| 21½ | 67.54 | 363.05 | 28½ | 89.53 | 637.94 | 35½ | 111.5 | 989.80 |
| | 67.93 | 367.28 | | 89.92 | 643.54 | | 111.9 | 996.78 |
| 21¾ | 68.32 | 371.54 | 28¾ | 90.32 | 649.18 | 35¾ | 112.3 | 1003.7 |
| | 68.72 | 375.82 | | 90.71 | 654.83 | | 112.7 | 1010.8 |
| 22 | 69.11 | 380.13 | 29 | 91.10 | 660.52 | 36 | 113.0 | 1017.8 |
| | 69.50 | 384.46 | | 91.49 | 666.22 | | 113.4 | 1024.9 |
| 22¼ | 69.90 | 388.82 | 29¼ | 91.89 | 671.95 | 36¼ | 113.8 | 1032.0 |
| | 70.29 | 393.20 | | 92.28 | 677.71 | | 114.2 | 1039.1 |
| 22½ | 70.68 | 397.60 | 29½ | 92.67 | 683.49 | 36½ | 114.6 | 1049.3 |
| | 71.07 | 402.03 | | 93.06 | 689.29 | | 115.0 | 1053.5 |
| 22¾ | 71.47 | 406.49 | 29¾ | 93.46 | 695.12 | 36¾ | 115.4 | 1060.7 |
| | 71.86 | 410.97 | | 93.85 | 700.98 | | 115.8 | 1067.9 |
| 23 | 72.25 | 415.47 | 30 | 94.24 | 706.86 | 37 | 116.2 | 1075.2 |
| | 72.64 | 420.00 | | 94.64 | 712.76 | | 116.6 | 1082.4 |
| 23¼ | 73.04 | 424.55 | 30¼ | 95.03 | 718.69 | 37¼ | 117.0 | 1089.7 |
| | 73.43 | 429.13 | | 95.42 | 724.64 | | 117.4 | 1097.1 |
| 23½ | 73.82 | 433.73 | 30½ | 95.81 | 730.61 | 37½ | 117.8 | 1104.4 |
| | 74.21 | 438.30 | | 96.21 | 736.61 | | 118.2 | 1111.8 |
| 23¾ | 74.61 | 443.01 | 30¾ | 96.60 | 742.64 | 37¾ | 118.6 | 1119.2 |
| | 75.00 | 447.69 | | 96.99 | 748.69 | | 118.9 | 1126.6 |
| 24 | 75.39 | 452.39 | 31 | 97.38 | 754.76 | 38 | 119.3 | 1134.1 |
| | 75.79 | 457.11 | | 97.78 | 760.86 | | 119.7 | 1141.5 |
| 24¼ | 76.18 | 461.86 | 31¼ | 98.17 | 766.99 | 38¼ | 120.1 | 1149.0 |
| | 76.57 | 466.63 | | 98.56 | 773.14 | | 120.5 | 1156.6 |
| 24½ | 76.96 | 471.43 | 31½ | 98.96 | 779.31 | 38½ | 120.9 | 1164.1 |
| | 77.36 | 476.25 | | 99.35 | 785.51 | | 121.3 | 1171.7 |
| 24¾ | 77.75 | 481.10 | 31¾ | 99.74 | 791.73 | 38¾ | 121.7 | 1179.3 |
| | 78.14 | 485.97 | | 100.1 | 797.97 | | 122.1 | 1186.9 |
| 25 | 78.54 | 490.87 | 32 | 100.5 | 804.24 | 39 | 122.5 | 1194.5 |
| | 78.93 | 495.79 | | 100.9 | 810.54 | | 122.9 | 1202.2 |
| 25¼ | 79.32 | 500.74 | 32¼ | 101.3 | 816.86 | 39¼ | 123.3 | 1209.9 |
| | 79.71 | 505.71 | | 101.7 | 823.21 | | 123.7 | 1217.6 |

## Circumferences and Areas of Circles.—Continued.

| Diam. | Circ. | Area. | Diam. | Circ. | Area. | Diam. | Circ. | Area. |
|---|---|---|---|---|---|---|---|---|
| 39½ — | 124.0 | 1225.4 | 46½ — | 146.0 | 1698.2 | 53½ — | 168.0 | 2248.0 |
| | 124.4 | 1233.1 | | 146.4 | 1707.3 | | 168.4 | 2258.5 |
| 39¾ — | 124.8 | 1240.9 | 46¾ — | 146.8 | 1716.5 | 53¾ — | 168.8 | 2269.0 |
| | 125.2 | 1248.7 | | 147.2 | 1725.7 | | 169.2 | 2279.6 |
| 40 — | 125.6 | 1256.6 | 47 — | 147.6 | 1734.9 | 54 — | 169.6 | 2290.2 |
| | 126.0 | 1264.5 | | 148.0 | 1744.1 | | 170.0 | 2300.8 |
| 40¼ — | 126.4 | 1272.3 | 47¼ — | 148.4 | 1753.4 | 54¼ — | 170.4 | 2311.4 |
| | 126.8 | 1280.3 | | 148.8 | 1762.7 | | 170.8 | 2322.1 |
| 40½ — | 127.2 | 1288.2 | 47½ — | 149.2 | 1772.0 | 54½ — | 171.2 | 2332.8 |
| | 127.6 | 1296.2 | | 149.6 | 1781.3 | | 171.6 | 2343.5 |
| 40¾ — | 128.0 | 1304.2 | 47¾ — | 150.0 | 1790.7 | 54¾ — | 172.0 | 2354.2 |
| | 128.4 | 1312.2 | | 150.4 | 1800.1 | | 172.3 | 2365.0 |
| 41 — | 128.8 | 1320.2 | 48 — | 150.7 | 1809.5 | 55 — | 172.7 | 2375.8 |
| | 129.1 | 1328.3 | | 151.1 | 1818.9 | | 173.1 | 2386.6 |
| 41¼ — | 129.5 | 1336.4 | 48¼ — | 151.5 | 1828.4 | 55¼ — | 173.5 | 2397.4 |
| | 129.9 | 1344.5 | | 151.9 | 1837.9 | | 173.9 | 2408.3 |
| 41½ — | 130.3 | 1352.6 | 48½ — | 152.3 | 1847.4 | 55½ — | 174.3 | 2419.2 |
| | 130.7 | 1360.8 | | 152.7 | 1856.9 | | 174.7 | 2430.1 |
| 41¾ — | 131.1 | 1369.0 | 48¾ — | 153.1 | 1866.5 | 55¾ — | 175.1 | 2441.0 |
| | 131.5 | 1377.2 | | 153.5 | 1876.1 | | 175.5 | 2452.0 |
| 42 — | 131.9 | 1385.4 | 49 — | 153.9 | 1885.7 | 56 — | 175.9 | 2463.0 |
| | 132.3 | 1393.7 | | 154.3 | 1895.3 | | 176.3 | 2474.0 |
| 42¼ — | 132.7 | 1401.9 | 49¼ — | 154.7 | 1905.0 | 56¼ — | 176.7 | 2485.0 |
| | 133.1 | 1410.2 | | 155.1 | 1914.7 | | 177.1 | 2496.1 |
| 42½ — | 133.5 | 1418.6 | 49½ — | 155.5 | 1924.4 | 56½ — | 177.5 | 2507.1 |
| | 133.9 | 1426.9 | | 155.9 | 1934.1 | | 177.8 | 2518.2 |
| 42¾ — | 134.3 | 1435.3 | 49¾ — | 156.2 | 1943.9 | 56¾ — | 178.2 | 2529.4 |
| | 134.6 | 1443.7 | | 156.6 | 1953.6 | | 178.6 | 2540.5 |
| 43 — | 135.0 | 1452.2 | 50 — | 157.0 | 1963.5 | 57 — | 179.0 | 2551.7 |
| | 135.4 | 1460.6 | | 157.4 | 1973.3 | | 179.4 | 2562.9 |
| 43¼ — | 135.8 | 1469.1 | 50¼ — | 157.8 | 1983.1 | 57¼ — | 179.8 | 2574.1 |
| | 136.2 | 1477.6 | | 158.2 | 1993.0 | | 180.2 | 2585.4 |
| 43½ — | 136.6 | 1486.1 | 50½ — | 158.6 | 2002.9 | 57½ — | 180.6 | 2596.7 |
| | 137.0 | 1494.7 | | 159.0 | 2012.8 | | 181.0 | 2608.0 |
| 43¾ — | 137.4 | 1503.3 | 50¾ — | 159.4 | 2022.8 | 57¾ — | 181.4 | 2619.3 |
| | 137.8 | 1511.9 | | 159.8 | 2032.8 | | 181.8 | 2630.7 |
| 44 — | 138.2 | 1520.5 | 51 — | 160.2 | 2042.8 | 58 — | 182.2 | 2642.0 |
| | 138.6 | 1529.1 | | 160.6 | 2052.8 | | 182.6 | 2653.4 |
| 44¼ — | 139.0 | 1537.8 | 51¼ — | 161.0 | 2062.9 | 58¼ — | 182.9 | 2664.9 |
| | 139.4 | 1546.5 | | 161.3 | 2072.9 | | 183.3 | 2676.3 |
| 44½ — | 139.8 | 1555.2 | 51½ — | 161.7 | 2083.0 | 58½ — | 183.7 | 2687.8 |
| | 140.1 | 1564.0 | | 162.1 | 2093.2 | | 184.1 | 2699.3 |
| 44¾ — | 140.5 | 1572.8 | 51¾ — | 162.5 | 2103.3 | 58¾ — | 184.5 | 2710.8 |
| | 140.9 | 1581.6 | | 162.9 | 2113.5 | | 184.9 | 2722.4 |
| 45 — | 141.3 | 1590.4 | 52 — | 163.3 | 2123.7 | 59 — | 185.3 | 2733.9 |
| | 141.7 | 1599.2 | | 163.7 | 2133.9 | | 185.7 | 2745.5 |
| 45¼ — | 142.1 | 1608.1 | 52¼ — | 164.1 | 2144.1 | 59¼ — | 186.1 | 2757.1 |
| | 142.5 | 1617.0 | | 164.5 | 2154.4 | | 186.5 | 2768.8 |
| 45½ — | 142.9 | 1625.9 | 52½ — | 164.9 | 2164.7 | 59½ — | 186.9 | 2780.5 |
| | 143.3 | 1634.9 | | 165.3 | 2175.0 | | 187.3 | 2792.2 |
| 45¾ — | 143.7 | 1643.8 | 52¾ — | 165.7 | 2185.4 | 59¾ — | 187.7 | 2803.9 |
| | 144.1 | 1652.8 | | 166.1 | 2195.7 | | 188.1 | 2815.6 |
| 46 — | 144.5 | 1661.9 | 53 — | 166.5 | 2206.1 | 60 — | 188.4 | 2827.4 |
| | 144.9 | 1670.9 | | 166.8 | 2216.6 | | 188.8 | 2839.2 |
| 46¼ — | 145.2 | 1680.0 | 53¼ — | 167.2 | 2227.0 | 60¼ — | 189.2 | 2851.0 |
| | 145.6 | 1689.1 | | 167.6 | 2237.5 | | 189.6 | 2862.8 |

## Circumferences and Areas of Circles.—Continued.

| Diam. | Circ. | Area. | Diam. | Circ. | Area. | Diam. | Circ. | Area. |
|---|---|---|---|---|---|---|---|---|
| 60½ | 190.0 | 2874.7 | 67½ | 212.0 | 3578.4 | 74½ | 234.0 | 4359.1 |
| | 190.4 | 2886.6 | | 212.4 | 3591.7 | | 234.4 | 4373.8 |
| 60¾ | 190.8 | 2898.5 | 67¾ | 212.8 | 3605.0 | 74¾ | 234.8 | 4388.4 |
| | 191.2 | 2910.5 | | 213.2 | 3618.3 | | 235.2 | 4403.1 |
| 61 | 191.6 | 2922.4 | 68 | 213.6 | 3631.6 | 75 | 235.6 | 4417.8 |
| | 192.0 | 2934.4 | | 214.0 | 3645.0 | | 236.0 | 4432.6 |
| 61¼ | 192.4 | 2946.4 | 68¼ | 214.4 | 3658.4 | 75¼ | 236.4 | 4447.3 |
| | 192.8 | 2958.5 | | 214.8 | 3671.8 | | 236.7 | 4462.1 |
| 61½ | 193.2 | 2970.5 | 68½ | 215.1 | 3685.2 | 75½ | 237.1 | 4476.9 |
| | 193.6 | 2982.6 | | 215.5 | 3698.7 | | 237.5 | 4491.8 |
| 61¾ | 193.9 | 2994.7 | 68¾ | 215.9 | 3712.2 | 75¾ | 237.9 | 4506.6 |
| | 194.3 | 3006.9 | | 216.3 | 3725.7 | | 238.3 | 4521.5 |
| 62 | 194.7 | 3019.0 | 69 | 216.7 | 3739.2 | 76 | 238.7 | 4536.4 |
| | 195.1 | 3031.2 | | 217.1 | 3752.8 | | 239.1 | 4551.4 |
| 62¼ | 195.5 | 3043.4 | 69¼ | 217.5 | 3766.4 | 76¼ | 239.5 | 4566.3 |
| | 195.9 | 3055.7 | | 217.9 | 3780.0 | | 239.9 | 4581.3 |
| 62½ | 196.3 | 3067.9 | 69½ | 218.3 | 3793.6 | 76½ | 240.3 | 4596.3 |
| | 196.7 | 3080.2 | | 218.7 | 3807.3 | | 240.7 | 4611.3 |
| 62¾ | 197.1 | 3092.5 | 69¾ | 219.1 | 3821.0 | 76¾ | 241.1 | 4626.4 |
| | 197.5 | 3104.8 | | 219.5 | 3834.7 | | 241.5 | 4641.5 |
| 63 | 197.9 | 3117.2 | 70 | 219.9 | 3848.4 | 77 | 241.9 | 4656.6 |
| | 198.3 | 3129.6 | | 220.3 | 3862.2 | | 242.2 | 4671.7 |
| 63¼ | 198.7 | 3142.0 | 70¼ | 220.6 | 3875.9 | 77¼ | 242.6 | 4686.9 |
| | 199.0 | 3144.4 | | 221.0 | 3889.8 | | 243.0 | 4702.1 |
| 63½ | 199.4 | 3166.9 | 70½ | 221.4 | 3903.6 | 77½ | 243.4 | 4717.3 |
| | 199.8 | 3179.4 | | 221.8 | 3917.4 | | 243.8 | 4732.5 |
| 63¾ | 200.2 | 3191.9 | 70¾ | 222.2 | 3931.3 | 77¾ | 244.2 | 4747.7 |
| | 200.6 | 3204.4 | | 222.6 | 3945.2 | | 244.6 | 4763.0 |
| 64 | 201.0 | 3216.9 | 71 | 223.0 | 3959.2 | 78 | 245.0 | 4778.3 |
| | 201.4 | 3229.5 | | 223.4 | 3973.1 | | 245.4 | 4793.7 |
| 64¼ | 201.8 | 3242.1 | 71¼ | 223.8 | 3987.1 | 78¼ | 245.8 | 4809.0 |
| | 202.2 | 3254.8 | | 224.2 | 4001.1 | | 246.2 | 4824.4 |
| 64½ | 202.6 | 3267.4 | 71½ | 224.6 | 4015.1 | 78½ | 246.6 | 4839.8 |
| | 203.0 | 3280.1 | | 225.0 | 4029.2 | | 247.0 | 4855.2 |
| 64¾ | 203.4 | 3292.8 | 71¾ | 225.4 | 4043.2 | 78¾ | 247.4 | 4870.7 |
| | 203.8 | 3305.5 | | 225.8 | 4067.3 | | 247.7 | 4886.1 |
| 65 | 204.2 | 3318.3 | 72 | 226.1 | 4071.5 | 79 | 248.1 | 4901.6 |
| | 204.5 | 3331.0 | | 226.5 | 4085.6 | | 248.5 | 4917.2 |
| 65¼ | 204.9 | 3343.8 | 72¼ | 226.9 | 4099.8 | 79¼ | 248.9 | 4932.7 |
| | 205.3 | 3356.7 | | 227.3 | 4114.0 | | 249.3 | 4948.3 |
| 65½ | 205.7 | 3369.5 | 72½ | 227.7 | 4128.2 | 79½ | 249.7 | 4963.9 |
| | 206.1 | 3382.4 | | 228.1 | 4142.5 | | 250.1 | 4979.5 |
| 65¾ | 206.5 | 3395.3 | 72¾ | 228.5 | 4156.7 | 79¾ | 250.5 | 4995.1 |
| | 206.9 | 3408.2 | | 228.9 | 4171.0 | | 250.9 | 5010.8 |
| 66 | 207.3 | 3421.2 | 73 | 229.3 | 4185.3 | 80 | 251.3 | 5026.5 |
| | 207.7 | 3434.1 | | 229.7 | 4199.7 | | 251.7 | 5042.2 |
| 66¼ | 208.1 | 3447.1 | 73¼ | 230.1 | 4214.1 | 80¼ | 252.1 | 5058.0 |
| | 208.5 | 3460.1 | | 230.5 | 4228.5 | | 252.5 | 5073.7 |
| 66½ | 208.9 | 3473.2 | 73½ | 230.9 | 4242.9 | 80½ | 252.8 | 5089.5 |
| | 209.3 | 3486.3 | | 231.3 | 4257.3 | | 253.2 | 5105.4 |
| 66¾ | 209.7 | 3499.3 | 73¾ | 231.6 | 4271.8 | 80¾ | 253.6 | 5121.2 |
| | 210.0 | 3512.5 | | 232.0 | 4286.3 | | 254.0 | 5137.1 |
| 67 | 210.4 | 3525.6 | 74 | 232.4 | 4300.8 | 81 | 254.4 | 5153.0 |
| | 210.9 | 3538.8 | | 232.8 | 4315.3 | | 254.8 | 5168.9 |
| 67¼ | 211.2 | 3552.0 | 74¼ | 233.2 | 4329.9 | 81¼ | 255.2 | 5184.8 |
| | 211.6 | 3565.2 | | 233.6 | 4344.5 | | 255.6 | 5200.8 |

## Circumferences and Areas of Circles.—Concluded.

| Diam. | Circ. | Area. | Diam. | Circ. | Area. | Diam. | Circ. | Area. |
|---|---|---|---|---|---|---|---|---|
| 81½ | 256.0 | 5216.8 | 88 | 276.4 | 6082.1 | 94½ | 296.8 | 7013.8 |
| | 256.4 | 5232.8 | | 276.8 | 6099.4 | | 297.2 | 7032.3 |
| 81¾ | 256.8 | 5248.8 | 88¼ | 277.2 | 6116.7 | 94¾ | 297.6 | 7050.9 |
| | 257.2 | 5264.9 | | 277.6 | 6134.0 | | 298.0 | 7069.5 |
| 82 | 257.6 | 5281.0 | 88½ | 278.0 | 6151.4 | 95 | 298.4 | 7088.2 |
| | 258.0 | 5297.1 | | 278.4 | 6168.8 | | 298.8 | 7106.9 |
| 82¼ | 258.3 | 5313.2 | 88¾ | 278.8 | 6186.2 | 95¼ | 299.2 | 7125.5 |
| | 258.7 | 5329.4 | | 279.2 | 6203.6 | | 299.6 | 7144.3 |
| 82½ | 259.1 | 5345.6 | 89 | 279.6 | 6221.1 | 95½ | 300.0 | 7163.0 |
| | 259.5 | 5361.8 | | 279.9 | 6238.6 | | 300.4 | 7181.8 |
| 82¾ | 259.9 | 5378.0 | 89¼ | 280.3 | 6256.1 | 95¾ | 300.8 | 7200.5 |
| | 260.3 | 5394.3 | | 280.7 | 6273.6 | | 301.2 | 7219.4 |
| 83 | 260.7 | 5410.6 | 89½ | 281.1 | 6291.2 | 96 | 301.6 | 7238.2 |
| | 261.1 | 5426.9 | | 281.5 | 6308.8 | | 301.9 | 7257.1 |
| 83¼ | 261.5 | 5443.2 | 89¾ | 281.9 | 6326.4 | 96¼ | 302.3 | 7275.9 |
| | 261.9 | 5459.6 | | 282.3 | 6344.0 | | 302.7 | 7294.9 |
| 83½ | 262.3 | 5476.0 | 90 | 282.7 | 6361.7 | 96½ | 303.1 | 7313.8 |
| | 262.7 | 5492.4 | | 283.1 | 6379.4 | | 303.5 | 7332.8 |
| 83¾ | 263.1 | 5508.8 | 90¼ | 283.5 | 6397.1 | 96¾ | 303.9 | 7341.7 |
| | 263.5 | 5525.3 | | 283.9 | 6414.8 | | 304.3 | 7370.7 |
| 84 | 263.8 | 5541.7 | 90½ | 284.3 | 6432.6 | 97 | 304.7 | 7389.8 |
| | 264.2 | 5558.2 | | 284.7 | 6450.4 | | 305.1 | 7408.8 |
| 84¼ | 264.6 | 5574.8 | 90¾ | 285.1 | 6468.2 | 97¼ | 305.5 | 7427.9 |
| | 265.0 | 5591.3 | | 285.4 | 6486.0 | | 305.9 | 7447.0 |
| 84½ | 265.4 | 5607.9 | 91 | 285.8 | 6503.8 | 97½ | 306.3 | 7466.2 |
| | 265.8 | 5624.5 | | 286.2 | 6521.7 | | 306.6 | 7485.3 |
| 84¾ | 266.2 | 5641.1 | 91¼ | 286.6 | 6539.6 | 97¾ | 307.0 | 7504.5 |
| | 266.6 | 5657.8 | | 287.0 | 6557.6 | | 307.4 | 7523.7 |
| 85 | 267.0 | 5674.5 | 91½ | 287.4 | 6575.5 | 98 | 307.8 | 7542.9 |
| | 267.4 | 5691.2 | | 287.8 | 6593.5 | | 308.2 | 7562.2 |
| 85¼ | 267.8 | 5707.9 | 91¾ | 288.2 | 6611.5 | 98¼ | 308.6 | 7581.5 |
| | 268.2 | 5724.6 | | 288.6 | 6629.5 | | 309.0 | 7600.8 |
| 85½ | 268.6 | 5741.4 | 92 | 289.0 | 6647.6 | 98½ | 309.4 | 7620.1 |
| | 268.9 | 5758.2 | | 289.4 | 6665.7 | | 309.8 | 7639.4 |
| 85¾ | 269.3 | 5775.0 | 92¼ | 289.8 | 6683.8 | 98¾ | 310.2 | 7658.8 |
| | 269.7 | 5791.9 | | 290.2 | 6701.9 | | 310.6 | 7678.2 |
| 86 | 270.1 | 5808.8 | 92½ | 290.5 | 6720.0 | 99 | 311.0 | 7697.7 |
| | 270.5 | 5825.7 | | 290.9 | 6738.2 | | 311.4 | 7717.1 |
| 86¼ | 270.9 | 5842.6 | 92¾ | 291.3 | 6756.4 | 99¼ | 311.8 | 7736.6 |
| | 271.3 | 5859.5 | | 291.7 | 6776.4 | | 312.1 | 7756.1 |
| 86½ | 271.7 | 5876.5 | 93 | 292.1 | 6792.9 | 99½ | 312.5 | 7775.6 |
| | 272.1 | 5893.5 | | 292.5 | 6811.1 | | 312.9 | 7795.2 |
| 86¾ | 272.5 | 5910.5 | 93¼ | 292.9 | 6829.4 | 99¾ | 313.3 | 7814.7 |
| | 272.9 | 5927.6 | | 293.3 | 6847.8 | | 313.7 | 7834.3 |
| 87 | 273.3 | 5944.6 | 93½ | 293.7 | 6866.1 | 100 | 314.1 | 7853.9 |
| | 273.7 | 5961.7 | | 294.1 | 6884.5 | | 314.5 | 7854.0 |
| 87¼ | 274.1 | 5978.9 | 93¾ | 294.5 | 6902.9 | 100¼ | 314.9 | 7893.3 |
| | 274.4 | 5996.0 | | 294.9 | 6921.3 | | 315.3 | 7913.1 |
| 87½ | 274.8 | 6013.2 | 94 | 295.3 | 6939.7 | 100½ | 315.7 | 7932.7 |
| | 275.2 | 6030.4 | | 295.7 | 6958.2 | | 316.0 | 7942.4 |
| 87¾ | 275.6 | 6047.6 | 94½ | 296.0 | 6976.7 | 100¾ | 316.4 | 7972.2 |
| | 276.0 | 6064.8 | | 296.4 | 6995.2 | | 316.8 | 7991.9 |

## Revolutions per Mile of Wheels of Various Diameters.

| Diameter in inches. | Revolutions per mile. | Diameter in inches. | Revolutions per mile. | Diameter in inches. | Revolutions per mile. |
|---|---|---|---|---|---|
| 18 | 1120.44 | 44 | 458.36 | 70 | 288.11 |
| 19 | 1061.48 | 45 | 448.10 | 71 | 284.05 |
| 20 | 1008 40 | 46 | 438.43 | 72 | 280.11 |
| 21 | 960.30 | 47 | 429.10 | 73 | 276.27 |
| 22 | 916.73 | 48 | 420.17 | 74 | 272.11 |
| 23 | 876.80 | 49 | 411.52 | 75 | 268.90 |
| 24 | 840.34 | 50 | 403.36 | 76 | 265.36 |
| 25 | 806.72 | 51 | 395.45 | 77 | 261.92 |
| 26 | 775.70 | 52 | 387.84 | 78 | 258.56 |
| 27 | 746.96 | 53 | 380.53 | 79 | 255.29 |
| 28 | 720.28 | 54 | 373.48 | 80 | 252.06 |
| 29 | 695.45 | 55 | 366.06 | 81 | 248.98 |
| 30 | 672.26 | 56 | 360.14 | 82 | 245.95 |
| 31 | 650.58 | 57 | 353.82 | 83 | 242.98 |
| 32 | 630.25 | 58 | 347.72 | 84 | 240.09 |
| 33 | 611.15 | 59 | 341.83 | 85 | 237.27 |
| 34 | 593.18 | 60 | 336.13 | 86 | 234.51 |
| 35 | 576.23 | 61 | 330.62 | 87 | 231.81 |
| 36 | 560.22 | 62 | 325.29 | 88 | 229.18 |
| 37 | 545.08 | 63 | 320.12 | 89 | 226.25 |
| 38 | 530.73 | 64 | 315.12 | 90 | 224.08 |
| 39 | 517.13 | 65 | 310.27 | 91 | 221.62 |
| 40 | 504.20 | 66 | 305.57 | 92 | 219.21 |
| 41 | 491.90 | 67 | 301.01 | 93 | 216.86 |
| 42 | 480.19 | 68 | 296.58 | 94 | 214.55 |
| 43 | 469.02 | 69 | 292.29 | 95 | 212.29 |
| | | | | 96 | 210.08 |

NOTE.—The piston speed in feet per mile may be found by multiplying the revolutions per mile by twice the length of the piston stroke in feet. The piston speed in feet per minute may be found by multiplying the piston speed in feet per mile, by the miles per hour, and divide by 60.

## Circumferences and Areas of Circles.—Concluded.

| Diam. | Circ. | Area. | Diam. | Circ. | Area. | Diam. | Circ. | Area. |
|---|---|---|---|---|---|---|---|---|
| 81½ — | 256.0 | 5216.8 | 88 — | 276.4 | 6082.1 | 94½ — | 296.8 | 7013.8 |
| | 256.4 | 5232.8 | | 276.8 | 6099.4 | | 297.2 | 7032.3 |
| 81¾ — | 256.8 | 5248.8 | 88¼ — | 277.2 | 6116.7 | 94¾ — | 297.6 | 7050.9 |
| | 257.2 | 5264.9 | | 277.6 | 6134.0 | | 298.0 | 7069.5 |
| 82 — | 257.6 | 5281.0 | 88½ — | 278.0 | 6151.4 | 95 — | 298.4 | 7088.2 |
| | 258.0 | 5297.1 | | 278.4 | 6168.8 | | 298.8 | 7106.9 |
| 82¼ — | 258.3 | 5313.2 | 88¾ — | 278.8 | 6186.2 | 95¼ — | 299.2 | 7125.5 |
| | 258.7 | 5329.4 | | 279.2 | 6203.6 | | 299.6 | 7144.3 |
| 82½ — | 259.1 | 5345.6 | 89 — | 279.6 | 6221.1 | 95½ — | 300.0 | 7163.0 |
| | 259.5 | 5361.8 | | 279.9 | 6238.6 | | 300.4 | 7181.8 |
| 82¾ — | 259.9 | 5378.0 | 89¼ — | 280.3 | 6256.1 | 95¾ — | 300.8 | 7200.5 |
| | 260.3 | 5394.3 | | 280.7 | 6278.6 | | 301.2 | 7219.4 |
| 83 — | 260.7 | 5410.6 | 89½ — | 281.1 | 6291.2 | 96 — | 301.5 | 7238.2 |
| | 261.1 | 5426.9 | | 281.5 | 6308.8 | | 301.9 | 7257.1 |
| 83¼ — | 261.5 | 5443.2 | 89¾ — | 281.9 | 6326.4 | 96¼ — | 302.3 | 7275.9 |
| | 261.9 | 5459.6 | | 282.3 | 6344.0 | | 302.7 | 7294.9 |
| 83½ — | 262.3 | 5476.0 | 90 — | 282.7 | 6361.7 | 96½ — | 303.1 | 7313.8 |
| | 262.7 | 5492.4 | | 283.1 | 6379.4 | | 303.5 | 7332.8 |
| 83¾ — | 263.1 | 5508.8 | 90¼ — | 283.5 | 6397.1 | 96¾ — | 303.9 | 7341.7 |
| | 263.5 | 5525.3 | | 283.9 | 6414.8 | | 304.3 | 7370.7 |
| 84 — | 263.8 | 5541.7 | 90½ — | 284.3 | 6432.6 | 97 — | 304.7 | 7389.8 |
| | 264.2 | 5558.2 | | 284.7 | 6450.4 | | 305.1 | 7408.8 |
| 84¼ — | 264.6 | 5574.8 | 90¾ — | 285.1 | 6468.2 | 97¼ — | 305.5 | 7427.9 |
| | 265.0 | 5591.3 | | 285.4 | 6486.0 | | 305.9 | 7447.0 |
| 84½ — | 265.4 | 5607.9 | 91 — | 285.8 | 6503.8 | 97½ — | 306.3 | 7466.2 |
| | 265.8 | 5624.5 | | 286.2 | 6521.7 | | 306.6 | 7485.3 |
| 84¾ — | 266.2 | 5641.1 | 91¼ — | 286.6 | 6539.6 | 97¾ — | 307.0 | 7504.5 |
| | 266.6 | 5657.8 | | 287.0 | 6557.6 | | 307.4 | 7523.7 |
| 85 — | 267.0 | 5674.5 | 91½ — | 287.4 | 6575.5 | 98 — | 307.8 | 7542.9 |
| | 267.4 | 5691.2 | | 287.8 | 6593.5 | | 308.2 | 7562.2 |
| 85¼ — | 267.8 | 5707.9 | 91¾ — | 288.2 | 6611.5 | 98¼ — | 308.6 | 7581.5 |
| | 268.2 | 5724.6 | | 288.6 | 6629.5 | | 309.0 | 7600.8 |
| 85½ — | 268.6 | 5741.4 | 92 — | 289.0 | 6647.6 | 98½ — | 309.4 | 7620.1 |
| | 268.9 | 5758.2 | | 289.4 | 6665.7 | | 309.8 | 7639.4 |
| 85¾ — | 269.3 | 5775.0 | 92¼ — | 289.8 | 6683.8 | 98¾ — | 310.2 | 7658.8 |
| | 269.7 | 5791.9 | | 290.2 | 6701.9 | | 310.6 | 7678.2 |
| 86 — | 270.1 | 5808.8 | 92½ — | 290.5 | 6720.0 | 99 — | 311.0 | 7697.7 |
| | 270.5 | 5825.7 | | 290.9 | 6738.2 | | 311.4 | 7717.1 |
| 86¼ — | 270.9 | 5842.6 | 92¾ — | 291.3 | 6756.4 | 99¼ — | 311.8 | 7736.6 |
| | 271.3 | 5859.5 | | 291.7 | 6776.4 | | 312.1 | 7756.1 |
| 86½ — | 271.7 | 5876.5 | 93 — | 292.1 | 6792.9 | 99½ — | 312.5 | 7775.6 |
| | 272.1 | 5893.5 | | 292.5 | 6811.1 | | 312.9 | 7795.2 |
| 86¾ — | 272.5 | 5910.5 | 93¼ — | 292.9 | 6829.4 | 99¾ — | 313.3 | 7814.7 |
| | 272.9 | 5927.6 | | 293.3 | 6847.8 | | 313.7 | 7834.3 |
| 87 — | 273.3 | 5944.6 | 93½ — | 293.7 | 6866.1 | 100 — | 314.1 | 7853.9 |
| | 273.7 | 5961.7 | | 294.1 | 6884.5 | | 314.5 | 7854.[illegible] |
| 87¼ — | 274.1 | 5978.9 | 93¾ — | 294.5 | 6902.9 | 100¼ — | 314.9 | 789[illegible] |
| | 274.4 | 5996.0 | | 294.9 | 6921.3 | | 315.3 | 79[illegible] |
| 87½ — | 274.8 | 6013.2 | 94 — | 295.3 | 6939.7 | 100½ — | 315.7 | [illegible] |
| | 275.2 | 6030.4 | | 295.7 | 6958.2 | | 316.[illegible] | [illegible] |
| 87¾ — | 275.6 | 6047.6 | 94½ — | 296.0 | 6976.7 | 100¾ — | 31[illegible] | [illegible] |
| | 276.0 | 6064.8 | | 296.4 | 6995.2 | | | |

## Revolutions per Mile of Wheels of Various Diameters.

| Diameter in inches. | Revolutions per mile. | Diameter in inches. | Revolutions per mile. | Diameter in inches. | Revolutions per mile. |
|---|---|---|---|---|---|
| 18 | 1120.44 | 44 | 458.36 | 70 | 288.11 |
| 19 | 1061.48 | 45 | 448.10 | 71 | 284.05 |
| 20 | 1008.40 | 46 | 438.43 | 72 | 280.11 |
| 21 | 960.38 | 47 | 429.10 | 73 | 276.27 |
| 22 | 916.73 | 48 | 420.17 | 74 | 272.11 |
| 23 | 876.88 | 49 | 411.52 | 75 | 268.90 |
| 24 | 840.34 | 50 | 403.36 | 76 | 265.36 |
| 25 | 806.72 | 51 | 395.45 | 77 | 261.92 |
| 26 | 775.70 | 52 | 387.84 | 78 | 258.56 |
| 27 | 746.96 | 53 | 380.53 | 79 | 255.29 |
| 28 | 720.28 | 54 | 373.48 | 80 | 252.06 |
| 29 | 695.45 | 55 | 366.68 | 81 | 248.98 |
| 30 | 672.26 | 56 | 360.14 | 82 | 245.95 |
| 31 | 650.58 | 57 | 353.82 | 83 | 242.98 |
| 32 | 630.25 | 58 | 347.72 | 84 | 240.09 |
| 33 | 611.15 | 59 | 341.83 | 85 | 237.27 |
| 34 | 593.18 | 60 | 336.13 | 86 | 234.51 |
| 35 | 576.23 | 61 | 330.62 | 87 | 231.81 |
| 36 | 560.22 | 62 | 325.29 | 88 | 229.18 |
| 37 | 545.08 | 63 | 320.12 | 89 | 226.25 |
| 38 | 530.73 | 64 | 315.12 | 90 | 224.08 |
| 39 | 517.13 | 65 | 310.27 | 91 | 221.62 |
| 40 | 504.20 | 66 | 305.57 | 92 | 219.21 |
| 41 | 491.90 | 67 | 301.01 | 93 | 216.86 |
| 42 | 480.19 | 68 | 296.58 | 94 | 214.55 |
| 43 | 469.02 | 69 | 292.29 | 95 | 212.29 |
| | | | | 96 | 210.08 |

NOTE.—The piston speed in feet per mile may be found by multiplying the [illegible] tions per mile by twice the length of the piston stroke in feet. [illegible] speed in feet per minute may be found by multiplying the [illegible] in [illegible] mile, by the miles per hour, and divide by 60.

# Table of Speeds.

| Time Per Mile | | Miles Per Hour. | Time Per Mile | | Miles Per Hour. | Time Per Mile | | Miles Per Hour. |
|---|---|---|---|---|---|---|---|---|
| Min. | Sec. | | Min. | Sec. | | Min. | Sec. | |
| 0 | 24 | 150 | 1 | 12 | 50 | 2 | 00 | 30 |
| 0 | 25 | 144 | 1 | 13 | 49.3 | 2 | 01 | 29.8 |
| 0 | 26 | 138.5 | 1 | 14 | 48.6 | 2 | 02 | 29.5 |
| 0 | 27 | 133.3 | 1 | 15 | 48 | 2 | 03 | 29.3 |
| 0 | 28 | 128.6 | 1 | 16 | 47.3 | 2 | 04 | 29 |
| 0 | 29 | 124.1 | 1 | 17 | 46.7 | 2 | 05 | 28.8 |
| 0 | 30 | 120 | 1 | 18 | 46.1 | 2 | 06 | 28.6 |
| 0 | 31 | 116.1 | 1 | 19 | 45.5 | 2 | 07 | 28.3 |
| 0 | 32 | 112.5 | 1 | 20 | 45 | 2 | 08 | 28.1 |
| 0 | 33 | 109 | 1 | 21 | 44.4 | 2 | 09 | 27.9 |
| 0 | 34 | 105.8 | 1 | 22 | 43.9 | 2 | 10 | 27.7 |
| 0 | 35 | 102.8 | 1 | 23 | 43.3 | 2 | 11 | 27.5 |
| 0 | 36 | 100 | 1 | 24 | 42.8 | 2 | 12 | 27.3 |
| 0 | 37 | 97.3 | 1 | 25 | 42.3 | 2 | 13 | 27 1 |
| 0 | 38 | 94.7 | 1 | 26 | 41.8 | 2 | 14 | 26.9 |
| 0 | 39 | 92.3 | 1 | 27 | 41.3 | 2 | 15 | 26.7 |
| 0 | 40 | 90 | 1 | 28 | 40.9 | 2 | 16 | 26.5 |
| 0 | 41 | 87.8 | 1 | 29 | 40.4 | 2 | 17 | 26.2 |
| 0 | 42 | 85.7 | 1 | 30 | 40 | 2 | 18 | 26.1 |
| 0 | 43 | 83.7 | 1 | 31 | 39.5 | 2 | 19 | 25.9 |
| 0 | 44 | 81.8 | 1 | 32 | 39.1 | 2 | 20 | 25.7 |
| 0 | 45 | 80 | 1 | 33 | 38.7 | 2 | 21 | 25.5 |
| 0 | 46 | 78.2 | 1 | 34 | 38.3 | 2 | 22 | 25.4 |
| 0 | 47 | 76.6 | 1 | 35 | 37.9 | 2 | 23 | 25.2 |
| 0 | 48 | 75 | 1 | 36 | 37.5 | 2 | 24 | 25 |
| 0 | 49 | 73.4 | 1 | 37 | 37.1 | 2 | 25 | 24.8 |
| 0 | 50 | 72 | 1 | 38 | 36.7 | 2 | 26 | 24.7 |
| 0 | 51 | 70.5 | 1 | 39 | 36.5 | 2 | 27 | 24.5 |
| 0 | 52 | 69.2 | 1 | 40 | 36 | 2 | 28 | 24.3 |
| 0 | 53 | 67.9 | 1 | 41 | 35.6 | 2 | 29 | 24.2 |
| 0 | 54 | 66.6 | 1 | 42 | 35.3 | 2 | 30 | 24 |
| 0 | 55 | 65.4 | 1 | 43 | 34.9 | 2 | 31 | 23.8 |
| 0 | 56 | 64.3 | 1 | 44 | 34.6 | 2 | 32 | 23.7 |
| 0 | 57 | 63.1 | 1 | 45 | 34.3 | 2 | 33 | 23.5 |
| 0 | 58 | 62 | 1 | 46 | 34 | 2 | 34 | 23.4 |
| 0 | 59 | 61 | 1 | 47 | 33.6 | 2 | 35 | 23.2 |
| 1 | 00 | 60 | 1 | 48 | 33.3 | 2 | 36 | 23.1 |
| 1 | 01 | 59 | 1 | 49 | 33 | 2 | 37 | 22.9 |
| 1 | 02 | 58 | 1 | 50 | 32.7 | 2 | 38 | 22.7 |
| 1 | 03 | 57.1 | 1 | 51 | 32.4 | 2 | 39 | 22.6 |
| 1 | 04 | 56.2 | 1 | 52 | 32.1 | 2 | 40 | 22.5 |
| 1 | 05 | 55.3 | 1 | 53 | 31.9 | 2 | 41 | 22.4 |
| 1 | 06 | 54.5 | 1 | 54 | 31.6 | 2 | 42 | 22.2 |
| 1 | 07 | 53.7 | 1 | 55 | 31.3 | 2 | 43 | 22.1 |
| 1 | 08 | 52.9 | 1 | 56 | 31 | 2 | 44 | 21.9 |
| 1 | 09 | 52.1 | 1 | 57 | 30.8 | 2 | 45 | 21.8 |
| 1 | 10 | 51.4 | 1 | 58 | 30.5 | 2 | 46 | 21.7 |
| 1 | 11 | 50.7 | 1 | 59 | 30.3 | 2 | 47 | 21.6 |

## Table of Speeds.—Continued.

| Time Per Mile | | Miles per Hour. | Time Per Mile | | Miles Per Hour. | Time Per Mile | | Miles per Hour. |
|---|---|---|---|---|---|---|---|---|
| Min. | Sec. | | Min. | Sec. | | Min. | Sec. | |
| 2 | 48 | 21.4 | 3 | 27 | 17.39 | 4 | 30 | 13.33 |
| 2 | 49 | 21.3 | 3 | 28 | 17.31 | 4 | 35 | 13.09 |
| 2 | 50 | 21.2 | 3 | 29 | 17.22 | 4 | 40 | 12.86 |
| 2 | 51 | 21.1 | 3 | 30 | 17.14 | 4 | 45 | 12.63 |
| 2 | 52 | 20.9 | 3 | 31 | 17.06 | 4 | 50 | 12.41 |
| 2 | 53 | 20.8 | 3 | 32 | 16.98 | 4 | 55 | 12.20 |
| 2 | 54 | 20.7 | 3 | 33 | 16.90 | 5 | 00 | 12. |
| 2 | 55 | 20.6 | 3 | 34 | 16.82 | 5 | 05 | 11.80 |
| 2 | 56 | 20.5 | 3 | 35 | 16.74 | 5 | 10 | 11.61 |
| 2 | 57 | 20.3 | 3 | 36 | 16.67 | 5 | 15 | 11.42 |
| 2 | 58 | 20.2 | 3 | 37 | 16.59 | 5 | 20 | 11.25 |
| 2 | 59 | 20.1 | 3 | 38 | 16.51 | 5 | 25 | 11.08 |
| 3 | 00 | 20 | 3 | 39 | 16.44 | 5 | 30 | 10.91 |
| 3 | 01 | 19.9 | 3 | 40 | 16.36 | 5 | 35 | 10.75 |
| 3 | 02 | 19.8 | 3 | 41 | 16.29 | 5 | 40 | 10.59 |
| 3 | 03 | 19.7 | 3 | 42 | 16.23 | 5 | 45 | 10.43 |
| 3 | 04 | 19.6 | 3 | 43 | 16.14 | 5 | 50 | 10.29 |
| 3 | 05 | 19.5 | 3 | 44 | 16.07 | 5 | 55 | 10.14 |
| 3 | 06 | 19.4 | 3 | 45 | 16. | 6 | 00 | 10 |
| 3 | 07 | 19.3 | 3 | 46 | 15.93 | 6 | 10 | 9.73 |
| 3 | 08 | 19.14 | 3 | 47 | 15.86 | 6 | 20 | 9.47 |
| 3 | 09 | 19.04 | 3 | 48 | 15.79 | 6 | 30 | 9.23 |
| 3 | 10 | 18.94 | 3 | 49 | 15.72 | 6 | 40 | 9 |
| 3 | 11 | 18.84 | 3 | 50 | 15.65 | 6 | 50 | 8.78 |
| 3 | 12 | 18.75 | 3 | 51 | 15.58 | 7 | 00 | 8.57 |
| 3 | 13 | 18.65 | 3 | 52 | 15.52 | 7 | 20 | 8.18 |
| 3 | 14 | 18.56 | 3 | 53 | 15.45 | 7 | 40 | 7.83 |
| 3 | 15 | 18.46 | 3 | 54 | 15.38 | 8 | 00 | 7.50 |
| 3 | 16 | 18.37 | 3 | 55 | 15.32 | 8 | 20 | 7.20 |
| 3 | 17 | 18.27 | 3 | 56 | 15.25 | 8 | 40 | 6.92 |
| 3 | 18 | 18.18 | 3 | 57 | 15.19 | 9 | 00 | 6.66 |
| 3 | 19 | 18.09 | 3 | 58 | 15.13 | 9 | 30 | 6.32 |
| 3 | 20 | 18. | 3 | 59 | 15.06 | 10 | 00 | 6 |
| 3 | 21 | 17.91 | 4 | 00 | 15. | 15 | 00 | 4 |
| 3 | 22 | 17.82 | 4 | 05 | 14.69 | 20 | 00 | 3 |
| 3 | 23 | 17.73 | 4 | 10 | 14.40 | 30 | 00 | 2 |
| 3 | 24 | 17.65 | 4 | 15 | 14.16 | 60 | 00 | 1 |
| 3 | 25 | 17.56 | 4 | 20 | 13.85 | | | |
| 3 | 26 | 17.48 | 4 | 25 | 13.58 | | | |

NOTE.—Miles per hour may be found by dividing 3600 by the number of seconds consumed in going one mile.

METHODS OF FINDING THE M. E. P,

When a planimeter such as Figure 396, Exhibit "A" or No. 3, Exhibit "B" can be had the M. E. P. can be readily calculated without any mathematical effort whatever, by simply following the directions given for the use of each in Exhibits "A" and "B," respectively.

Should the only planimeter available be one similar to that shown in Figure 395, Exhibit "A," or No. 2, Exhibit "B," the M. E. P. may be determined by finding the area of the diagram by using the planimeter. Then divide the area of the card by its length, and multiply the result by the scale of the spring used while taking the card.

$$\text{Formula M. E. P.} = \frac{A \times S}{L}$$

A=Area of Card.

S=Scale of Indicator Spring.

L=Length of the diagram.

If no planimeter is available, the M. E. P. may be found by dividing the diagram into any number of equal spaces. Take the distance between the diagram lines at a point central between the two lines bounding each space, distance to be measured by the proper scale of the spring, add these distances together and divide by the number of spaces, then multiply by the scale of the spring, and the result will be the M. E. P. per square inch.

$$\text{Formula M. E. P.} = \frac{T \times S}{N}$$

T=Total length of all lines.

S=Scale of Indicator Spring.

N=Number of spaces card is divided into.

FORMULA FOR CALCULATING THE HORSE POWER OF A LOCOMOTIVE.

No. 1.

$$\text{I. H. P.} = \frac{PLAN}{33000}$$

No. 2.

$$\text{I. H. P.} = \frac{238(PLD^2N)}{10,000,000}$$

In these formulæ the letters have the following significance:

P=M. E. P. in pounds per square inch.

L=Length of stroke in feet.

A=Area of piston in square inches.

N=Number of strokes per minute.

D=Diameter of piston in inches.

NOTE.—The results obtained by using the Formulæ No. 1 and No. 2 must be multiplied by 2 to get the total H. P. of a locomotive.

No. 3.

$$\text{I. H. P.} = \frac{4R\,(PAL)}{33000}$$

Formula No. 3 gives the total H. P. for both sides of the locomotive.

R=Revolutions of drivers per minute.

P=M. E. P.

A=Area of Piston.

L=Length of stroke in feet.

No. 4. $$\text{I. H. P.}=\frac{A \times P \times S}{33000}$$

A=Area of Piston in square inches.

P=M. E. P. per square inch.

S=Piston speed in feet per minute.

Double the result obtained by using Formula No. 4 to get the I. H. P. for both sides of the engine.

### THE HORSE POWER CONSTANT.

Where a number of cards from the same engine are to be calculated, for the purpose of tabulating the H. P., the work may be materially shortened by first establishing a horse power constant.

By a horse power constant is meant the horse power one cylinder will develop due to a force of one pound per square inch acting on the piston through one complete revolution of the driving wheel, or through twice the length of the stroke. The Formula is as follows :

$$C=\frac{A \times P \times 2S}{33000}$$

C=The constant.

A=The area of the piston in square inches.

P=M. E. P. or 1 pound.

S=The length of the stroke in feet.

Having established the H. P. constant to get the H. P., use the formula:

$$\text{H. P.}=R \times P \times C$$

R=Revolutions of driving wheels per minute.

P=M. E. P. in pounds per square inch.

C=The H. P. constant.

Double the amount obtained in the above formula to get the total H. P. of the locomotive.

The H. P. for compound engines is calculated the same as for simple engines ; each cylinder being figured as a separate engine and the total added together.

### THE TRACTIVE POWER OF A LOCOMOTIVE.

The tractive power of a locomotive is usually calculated from the Formula :

$$T=\frac{d^2 \times s \times p}{D}$$

T=Tractive power.

d=Diameter of cylinder.

s=Length of stroke in inches.
p=Mean effective pressure in pounds per square inch.
D=Diameter of driving wheels in inches.

When it is desirable to ascertain the tractive power of a locomotive at various speeds it will be found convenient to establish a tractive power constant; that is to find out what the tractive power is per pound of mean effective pressure acting on the piston. It will be given by the formula:

$$C=\frac{d^2 x \text{ s}}{D}$$

C=Constant.
d=Diameter of cylinder.
s=Stroke of piston in inches.
Then once determining the M. E. P. the tractive power may be found by multiplying the M. E. P. by the constant.

#### TRACTIVE POWER OF COMPOUND LOCOMOTIVES.

For a four cylinder compound:

$$T=\frac{C^2 \text{ x } S \text{ x } \frac{2}{3} P}{D}+\frac{c^2 \text{ x } S \text{ x } \frac{1}{4} P}{D}$$

For a two cylinder compound:

$$T=\frac{C^2 \text{ x } S \text{ x } \frac{2}{3} P}{D}$$

C=Diameter of high pressure cylinder in inches.
c=Diameter of low pressure cylinder in inches.
S=Stroke of piston in inches.
P=Boiler pressure in pounds.
D=Diameter of driving wheels in inches.
T=Tractive power.

For the two-cylindered compound this formula contemplates equal work being done by each cylinder, allowing a sufficient reduction of boiler pressure for M. E. P. to compensate for the necessary back pressure in H. P. cylinder.

## Resistance in Pounds per Ton of 2000 Pounds at Various Speeds on Straight and Level Track.

FORMULA: $R = 2 + \frac{V}{4}$

R = The Resistance.
V = The Speed in Miles per Hour.

| Miles per hour. | Resistance per ton | Miles per hour. | Resistance per ton | Miles per hour. | Resistance per ton. |
|---|---|---|---|---|---|
| 1 | 2.25 | 35 | 10.75 | 69 | 19.25 |
| 2 | 2.50 | 36 | 11 | 70 | 19.50 |
| 3 | 2.75 | 37 | 11.25 | 71 | 19.75 |
| 4 | 3 | 38 | 11.50 | 72 | 20 |
| 5 | 3.25 | 39 | 11.75 | 73 | 20.25 |
| 6 | 3.50 | 40 | 12 | 74 | 20.50 |
| 7 | 3.75 | 41 | 12.25 | 75 | 20.75 |
| 8 | 4 | 42 | 12.50 | 76 | 21 |
| 9 | 4.25 | 43 | 12.75 | 77 | 21.25 |
| 10 | 4.50 | 44 | 13 | 78 | 21.50 |
| 11 | 4.75 | 45 | 13.25 | 79 | 21.75 |
| 12 | 5 | 46 | 13.50 | 80 | 22 |
| 13 | 5.25 | 47 | 13.75 | 81 | 22.25 |
| 14 | 5.50 | 48 | 14 | 82 | 22.50 |
| 15 | 5.75 | 49 | 14.25 | 83 | 22.75 |
| 16 | 6 | 50 | 14.50 | 84 | 23 |
| 17 | 6.25 | 51 | 14.75 | 85 | 23.25 |
| 18 | 6.50 | 52 | 15 | 86 | 23.50 |
| 19 | 6.75 | 53 | 15.25 | 87 | 23.75 |
| 20 | 7 | 54 | 15.50 | 88 | 24 |
| 21 | 7.25 | 55 | 15.75 | 89 | 24.25 |
| 22 | 7.50 | 56 | 16 | 90 | 24.50 |
| 23 | 7.75 | 57 | 16.25 | 91 | 24.75 |
| 24 | 8 | 58 | 16.50 | 92 | 25 |
| 25 | 8.25 | 59 | 16.75 | 93 | 25.25 |
| 26 | 8.50 | 60 | 17 | 94 | 25.50 |
| 27 | 8.75 | 61 | 17.25 | 95 | 25.75 |
| 28 | 9 | 62 | 17.50 | 96 | 26 |
| 29 | 9.25 | 63 | 17.75 | 97 | 26.25 |
| 30 | 9.50 | 64 | 18 | 98 | 26.50 |
| 31 | 9.75 | 65 | 18.25 | 99 | 26.75 |
| 32 | 10 | 66 | 18.50 | 100 | 27 |
| 33 | 10.25 | 67 | 18.75 | | |
| 34 | 10.50 | 68 | 19 | | |

#### RESISTANCE IN POUNDS PER TON OF 2000 POUNDS DUE TO GRADE.

The resistance per ton due to grade is .375 or ⅜ pounds per foot of increase in grade per mile. That is the resistance of one ton on a grade of one foot per mile is .375 or ⅜ pounds. On a grade of two feet it is .75 or ¾ pounds, etc. Multiply the feet of grade per mile by ⅜, and the product will be the resistance in pounds for each ton hauled.

This formula applies to elevation on straight track, at only moving speed.

RESISTANCE PER TON OF 2000 POUNDS DUE TO CURVATURE.

The resistance of a ton increases .57 pounds for every degree of curvature.

Multiply the degrees of the curve by .57, and the product will be the resistance in pounds per ton due to the curve, at moving speed on level track.

When speed, grade and curvature all enter in the problem, proceed as follows: First, find the resistance necessary to maintain the speed; second, the resistance due to grade, and third, that due to the curvature of the track. Add them all together and the sum will be the resistance in pounds per ton for that speed, grade and curvature.

EXAMPLE.

What is the resistance per ton of a train at a speed of 40 miles per hour, on a 60 foot grade, around a five degree curve?

At 40 miles per hour the resistance per ton on a straight and level track is $R=2+\frac{V}{4}$. That is $R=2+\frac{40}{4}$ or 12 pounds. On a 60 foot grade the resistance per ton will be $60 \times \frac{3}{8}$ or 22.50 pounds. For a five degree curve we have the resistance per ton equal to 5 x .57 or 2.85 pounds. The total resistance is then under these conditions 12+22.50+2.85 or 37.35 pounds per ton.

## Decimal Equivalents of an inch in 1-64s.

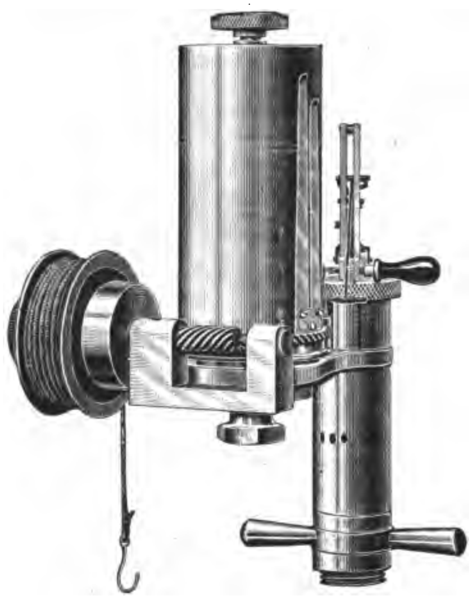
| | | | | | |
|---|---|---|---|---|---|
| 1-64 | .015625 | 23-64 | .359375 | 45-64 | .703125 |
| 1-32 | .03125 | 3-8 | .375 | 23-32 | .71875 |
| 3-64 | .046875 | 25-64 | .390625 | 47-64 | .734375 |
| 1-16 | .0625 | 13-32 | .40625 | 3-4 | .75 |
| 5-64 | .078125 | 27-64 | .421875 | 49-64 | .765625 |
| 3-32 | .09375 | 7-16 | .4375 | 25-32 | .78125 |
| 7-64 | .109375 | 29-64 | .453125 | 51-64 | .796875 |
| 1-8 | .125 | 15-32 | .46875 | 13-16 | .8125 |
| 9-64 | .140625 | 31-64 | .484375 | 53-64 | .828125 |
| 5-32 | .15625 | 1-2 | .5 | 27-32 | .84375 |
| 11-64 | .171875 | 33-64 | .515625 | 55-64 | .859375 |
| 3-16 | .1875 | 17-32 | .53125 | 7-8 | .875 |
| 13-64 | .203125 | 35-64 | .546875 | 57-64 | .890625 |
| 7-32 | .21875 | 9-16 | .5625 | 29-32 | .90625 |
| 15-64 | .234375 | 37-64 | .578125 | 59-64 | .921875 |
| 1-4 | .25 | 19-32 | .59375 | 15-16 | .9375 |
| 17-64 | .265625 | 39-64 | .609375 | 61-64 | .953125 |
| 9-32 | .28125 | 5-8 | .625 | 31-32 | .96875 |
| 19-64 | .296875 | 41-64 | .640625 | 63-64 | .984375 |
| 5-16 | .3125 | 21-32 | .65625 | 1 | .1000 |
| 21-64 | .328125 | 43-64 | .671875 | | |
| 11-32 | .34375 | 11-16 | .6875 | | |

# PART IV.

## Instruments and Their Description.

## EXHIBIT "A"

TABOR STEAM ENGINE INDICATORS.



The steam engine indicators that have come into prominent use have one essential plan of construction. There is a *steam cylinder* and a *paper drum.* The steam cylinder is designed to connect with the interior of the engine cylinder and to receive steam whenever the engine receives it. A piston, which is enclosed in the indicator steam cylinder, communicates motion to a pencil arranged to move in a straight line, the amount of movement being limited by the tension of a spiral spring against which the piston acts. The paper drum is a cylindrical shell mounted on its axis, and is made to turn forward and backward by a motion derived from the crosshead of the engine. A sheet of paper, or *card*, as it is named, is stretched upon the drum, and the pencil is brought to bear upon it. In this manner the instrument traces upon the paper a figure outline, termed the indicator diagram, which is the object sought. Since the motion of the paper drum is made to coincide with that of the piston of the engine, and the height to which the pencil rises varies accordiog to variations in the force of the steam, the indicator diagram presents a record of the pressure of steam in the engine cylinder at every point of the stroke.

To obtain well-defined diagrams with instruments of this description, it has been found desirable to employ a spring of high tension, so as to permit but a small movement of the piston. That a suitable height of the diagram may be obtained, this plan requires the multiplication of the movement of the piston. In the means that are employed for accomplishing this result, still preserving a straight line movement, the various forms of indicators that have been extensively used find their essential differences.

The Richard's Indicator, the first instrument of this kind that came into use, depended for the multiplication of the movement upon two levers, pivoted at opposite ends, and connected by a bar carrying the pencil. One of the levers at a point near the pivoted end received the motion of the piston. The use of this indicator upon engines running at high speed showed that the momentum of the multiplying device produced a disturbance in the action of the instrument which made the diagram inaccurate.

The Tabor Indicator was invented by Mr. Harris Tabor, of New York. The object sought by Mr Tabor was to better adapt the instrument to the attainment of smooth and accurate diagrams at high speeds. He endeavored to provide a movement, having such few parts, and those of such light weight, that a quick response to the action of the steam pressure should occur at any speed liable to be met in practice. The employment of high speeds is now of frequent occurrence on stationary and marine engines, and suitable provisions for indicating in those cases have become a recognized necessity.

Fig. 379.

PRICES.

Tabor Indicator, as above shown, fully nickel-plated, with one cylinder spring, one boxwood scale, two straight cocks, 100 cards, one screw driver, one bottle of porpoise oil, two wrenches, one extra drum spring, all enclosed in a substantial, well finished, black walnut box, with nickel-plated trimmings, each $85.00.

One three-way cock in place of the two straight cocks will be furnished without extra charge, if called for.

With each outfit of indicators we furnish, without charge, *Houghtaling's* book on the *Steam Engine Indicator and Its Appliances*, a valuable publication of 300 pages, describing the operation of the indicator on all classes of engines.

DESCRIPTION.

A prominent feature of the Tabor indicator lies in the means employed to communicate a *straight-line movement to the pencil.* A stationary plate containing a curved slot is firmly secured in an upright position to the cover of the steam cylinder. This slot serves as a guide and controls the motion of the pencil bar. The side of the pencil bar carries a roller which turns on a pin, and this is fitted so as to roll freely from end to end of the slot. The curve of the slot is so formed, and the pin attached to such a point, that the end of the pencil bar, which carries the pencil, moves up and down in a straight line, when the roller is moved from one end of the slot to the other. The curve of the slot just compensates the tendency of the pencil point to move in a circular arc, and a straight-line motion results. The outside of the curve is nearly a true circle with a radius of one inch.

The *steam cylinder* and the base of the paper drum are made in one casting. Inside the steam cylinder is a movable lining cylinder, within which the piston of the indicator works. This cylinder is attached by means of a screw thread at the bottom, and openings on opposite sides at the top are provided for the introduction of a tool for screwing it in or out. Openings through the sides of the outer cylinder are provided to allow the steam which leaks by the piston to escape.

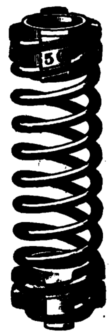
The *pencil mechanism* is carried by the cover of the outside cylinder. The cover proper is stationary, but a nicely fitted swivel plate, which extends over nearly the whole of the cover, is provided, and to this plate the direct attachment of the pencil mechanism is made. By means of the swivel plate, the pencil mechanism may be turned so as to bring the pencil into contact with the paper drum, as is done in the act of taking a diagram; this pencil mechanism is attached to the swivel plate by means of the vertical plate containing the slot, which has been referred to, and a small standard placed on the opposite side of the swivel plate for connecting the back link. The slotted plate is backed by another plate of a similar size, which serves to receive the pressure brought to bear on the pencil bar when taking diagrams, and to keep the pencil bar in place. The pencil mechanism consists of three pieces: the pencil bar, the back link, and the piston rod link. The two links

are parallel with each other in *every position they may assume.* The lower pivots of these links and the pencil point are always in the same straight line. If an imaginary link be supposed to connect the two in such a manner as to be parallel with the pencil bar, the combination would form an exact pantograph. The slot and roller serve the purpose of this imaginary link; the connection between the piston and the pencil mechanism is made by means of a steel piston rod. At the upper end, where it passes through the cover, it is hollow, and has an outside diameter measuring 3/16 of an inch. At the lower end it is solid, and its diameter is reduced. It connects with the piston through a ball and socket joint. The socket forms an independent piece, which fits into a square hole in the center of the piston, and is fastened by means of a central stem provided with a screw, which passes through the hole and receives a nut applied from the under side. The nut has a flat-sided head, so as to be readily operated with the fingers. A number of shallow grooves are cut upon the outside of the piston to serve as a so called water packing.

One of the most important features of an indicator is its *parallel motion.* The correctness of the parallel motion of the Tabor Indicator is such that at all times, and at every point on the diagram within the reach of the pencil point, the extreme end of the pencil bar will record a vertical travel or movement of *just five times* that of the indicator piston, which can be tested and proved to the satisfaction of anyone desiring proof, by the use of a micrometer screw device, which we will loan to anyone who may desire to make test of the instrument.

The *springs* are of the Duplex type, made of two spiral coils of wire, strongly held at their ends in brass fittings. The wires are so mounted that the ends of each coil are connected on opposite sides of the fitting. This arrangement equalizes side strain on the spring, and ensures the piston moving central in the cylinder, thus avoiding excessive friction caused by a single coil spring in forcing the piston against the side of the cylinder. The threads by which the spring is connected are cut on the inside of its fittings, and suitable threaded projections on the under side of the cover and on the upper side of the piston, respectively, are provided for securing the spring in place. These springs are adjusted under steam pressure, and are, consequently, correct only when used with *steam.* If required for *water,* or other purposes, it should be so stated in order. It should be borne in mind that a spring is liable to become impaired by continued use, and for important work its accuracy should always be tested beforehand.

The maximum safe steam pressures above atmosphere, to which the various springs made for the indicator can be subjected, are given in the following table:



DUPLEX SPRING

| Scale of Spring. | Safe Maximum Pressure. Lbs pressure per sq. in. | | Scale of Spring. | Lbs. pressure per sq. in. | |
|---|---|---|---|---|---|
| | To 200 Rev. | To 300 Rev. | | To 200 Rev. | To 300 Rev. |
| 8 | 10 | 6 | 48 | 112 | 95 |
| 10 | 15 | 10 | 50 | 120 | 100 |
| 12 | 20 | 15 | 60 | 140 | 115 |
| 16 | 28 | 22 | 64 | 152 | 125 |
| 20 | 40 | 32 | 80 | 180 | 145 |
| 24 | 48 | 40 | 100 | 200 | 160 |
| 30 | 70 | 58 | 120 | 240 | 195 |
| 32 | 75 | 62 | 150 | 290 | 250 |
| 40 | 95 | 80 | 200 | 375 | 330 |

The *paper drum* turns on a vertical steel shaft, secured at the lower end to the frame of the indicator. This drum is supported at the bottom by a carriage, which has a long vertical bearing on the shaft. It is guided at the top by the same shaft, which is lengthened for this purpose, the drum being closed in at the top and provided with a central bearing. The drum is held in place by a close fit, in the usual manner, and is easily removed by the hand when desired. Stops are provided on the inside of the drum at the bottom, with openings in the outside of the carriage to correspond, so as to prevent the drum from slipping. These are so placed that the position of the drum may be changed so as to take diagrams in the reverse position of the pencil mechanism when so desired. The drum is made of thin brass tubing, so as to be extremely light. Suitable strength is obtained by leaving a ring of thicker metal at the bottom and by employing the closed top. Spring clips are attaceed to the drum for holding the paper.

The *drum carriage* projects below the lower end of the drum, where it is provided with a groove for the reception of the driving cord. This groove has sufficient width for two complete turns of the cord. The drum spring, by which the backward movement of the drum is accomplished, consists of a flat spiral spring of the watch spring type, placed in a cavity under the drum carriage encircling the bearing. It is attached at one end to the frame below, and at the other end to the drum carriage. In its normal position the drum carriage is kept against a stop by means of the pull of the spring. The lower hub of the drum carriage rests directly on the spring case, while the opposite hub is in contact with a knurled thumb nut screwed and pinned to the central drum shaft. This thumb nut serves as a convenient means for winding or unwinding the paper drum spring, as by loosening the thin hexagon nut on the underside of the arm to which the spring case is secured by it, the thumb nut can then be turned in either direction until just the desired tension of the spring is obtained, when the thin nut should again be firmly tightened.

A simple form of *carrier pulley* serves to guide the driving cord on to the drum from any direction. A single pulley is mounted within a circular perpendicular plate, and the hole in the center of which coincides with the center of the driving cord with the periphery of the pulley. The plate can be turned about its center so as to swing the pulley into any desired angular position, and thereby lead the cord off in any desired direction. The plate is held by a circular frame, which serves also as a clamp, and the pulley is fixed in position by the use of the same nut which secures the frame to the pulley arm.

The instrument is *attached* by means of a coupling having but one thread. It is simple, like a common pipe coupling, and is operated by simply turning it in the proper direction, without exercising the care which the use of couplings having double threads require. The indicator cock is provided with a stop, so as to turn only the 90 degrees needed for opening and shutting. A complete revolution of the cock is impossible.

The *pressure of the pencil* on the paper drum is regulated by means of a screw, which passes through a projection on the slot plate and strikes against a small stop provided for the purpose, and secured to the frame. This screw is operated by a handle of sufficient size to be readily worked by the fingers, which also serves as a handle for turning the pencil mechanism back and forth, as is done in the act of taking diagrams. The screw, with handle, may be introduced and worked from either side, so as to use the pencil mechanism on either side of the paper drum.

The *end of the pencil bar* is shaped in the form of a thin tube for the reception of the pencil lead or metallic marking point. The tube is split apart on the side and yields to the slight pressure required to introduce the pencil, from either side, so as to mark on either side of the paper drum desired. The outside of the instrument in all its parts, excepting the pencil bar and links composing the pencil mechanism, is nickel-plated. The pencil mechanism is made of steel, hardened, and drawn to a spring temper, with blue finish.

Some of the dimensions of the parts of the instrument are as follows: Diameter of piston, 0.7978 inch; diameter of paper drum, 2.068 inches; stroke of paper drum, 5.5 inches; height of paper drum, 4 inches; diameter of wire used in 40 spring, 0.073 inch; number of times pencil mechanism multiplies piston motion, 5; range of motion of pencil, 3.25 inches.

The excellence of manufacture of the parts of the Tabor Indicator is a marked feature in the instrument, and particular attention is directed to this matter, as, from an engineering point of view, excellent workmanship in an instrument of this kind is of great importance. The perfection which is reached in its mechanical construction is revealed not only by a general examination of one of these instruments, but by a close inspection of every part; another point, and one that is usually overlooked, although of the highest importance, is, that the movement of the pencil should coincide exactly with the movement of the piston. The difficulty with all pencil movements on indicators is not to make the pencil point move in a perfectly

straight line, but to make the pencil move exactly so many times (five in this case) as fast as the piston at every part of its range. This has been perfectly accomplished in the Tabor Indicator. A result of the care in designing and constructing these instruments is a reduction of friction to the least possible amount. In a late report of a test of indicators made at the Brooklyn Navy Yard it was stated that the Tabor Indicator had 30 per cent. less weight of moving parts and 24.3 per cent. less friction than any others tested.

WITH HOUGHTALING REDUCING MOTION.

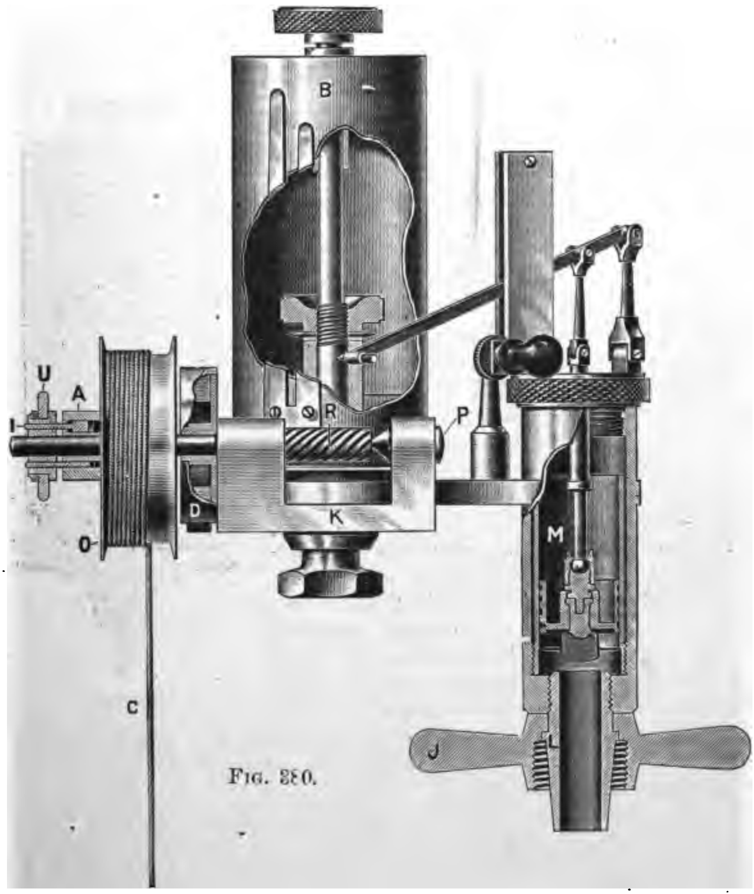



FIG. 280.

PRICES.

Tabor Indicator, as shown, fully nickel-plated, with one cylinder spring, one boxwood scale, two straight cocks, 100 cards, two screw drivers, one bottle porpoise oil, two wrenches, one extra drum spring, all enclosed in a

substantial, well-finished black walnut box, with nickel-plated trimmings, Each, $115.

One three-way cock, in place of two straight cocks, will be furnished without extra charge, if called for.

With each outfit of indicators we furnish, without charge, Houghtaling's book on the *Steam Engine Indicator and its Appliances*, a valuable publication of 300 pages, describing the operation of the indicator on all classes of engines.

*For prices of parts and extras, see page 112.*

DESCRIPTION.

This patent *reducing motion* is composed of a supporting base piece, K, provided with short standards that form bearings for the worm shaft, R, on which the flange pulley, O, is rotated, the outer bearing being a pivot, P, which receives the entire thrust of the shaft, R, thus reducing the friction to a minimum. It is connected directly to the indicator upon the projecting arm that supports the paper drum, B, and the teeth of the worm shaft, R, mesh directly into the teeth on the drum carriage. [Figure 380—A shows paper drum and the drum carriage with teeth cut thereon.] Connected with the base piece, K, is a spring case, D, and on the extreme end of the worm shaft, R, is secured a clutch consisting of a collar, A, through which the clutch pin, I, fastened to the flange holding swivel collar, U, slides freely.

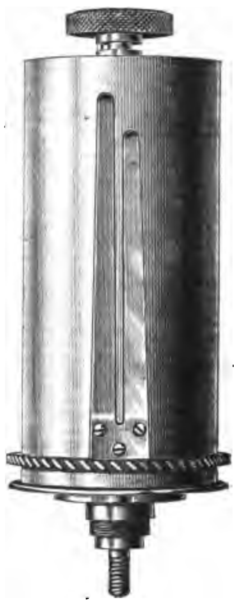


FIG. 380A

The *flange pulley*, O, runs freely and independently on worm shaft, R, and has on its outside a clutch-shaped hub. To this pulley, O, is connected the actuating cord, which should encircle it a sufficient number of times to have its length, when unwound, a little more than equal the length of the stroke of the engine. The other end of the cord is secured either to the cross-head of the engine, to a standard bolted thereto, or to any moving part that has an exact similar motion, and must be conected in line from the pulley, O.

Enclosed in the *spring case*, D, is a small, plain spiral steel spring which operates solely to return the pulley, O, back to its starting point, after it has been revolved in one direction by the forward movement of the engine cross-head. As this pulley, O, has an independent, rotating back-and-forth motion on the worm shaft, R, the necessity of unhooking the cord when the indicator is not being operated is entirely overcome. The paper drum, B, is rotated forward by means of the pulley, O, through its worm shaft, R, engaging with the worm gear, on the paper drum carriage, and in the oppo-

site direction, or backward, by the action of its own retracting spring. On top of paper drum, B, is a knurled thumb piece made with a projecting pin on its under side to engage with a similar pin located in the top of the drum, and is used by the operator for moving the paper drum slightly forward preparatory to taking a diagram, to prevent the drum from striking against its stop on the return motion.

With the indicator we furnish for use on the reducing motion, three different sized pulleys, which are of one-inch, two-inch and three and one-half inches diameter. These pulleys are sufficient for use in taking diagrams from engines having length strokes from six inches to four feet. Other sized pulleys can be furnished when required.

## TO OPERATE.

*To operate* this device, first select a pulley whose diameter is about one-twelfth of the length of the engine stroke in inches. See table below.

To properly place this pulley upon the worm shaft, R, first remove the clutch, and then slide the pulley on to the shaft, being particular that the small hole in the pulley brass disc sets over the profecting pin in the cover of the spring case, D. Then replace the clutch by pushing it on to the shaft as far as it will go, and secure it there by means of the set screw.

Next, place the indicator on the engine in such a position that the side of the pulley will be parallel with the motion of the cross-head. Run out the loose end of the cord to a distance of at least 12 or 18 inches *beyond the extreme forward travel* of the cross-head, still leaving a turn or two of the cord on the pulley unwound. While holding the cord, allow it to gradually recede and rewind itself on the pulley until its loose end has reached a point coincident with the extreme backward travel of the cross-head. If only a slight tension of the cord exists at this point it will be sufficient, and the cord may then be attached to the selected point on the cross-head. The cord-tension may always be adjusted, either by winding the cord on, or unwinding it from the pulley, as the case requires, one increasing and the other decreasing the tension.

A much lighter cord can be used in proportion as the sizes of the pulleys increase.

When the *cross-head*, with cord connected, is at its extreme forward travel, there should be just sufficient tension on the spring enclosed in the spring case, D, to take up all slackness of the cord when running, without overtaxing the spring. If upon starting the engine, the cord should at first run unevenly on the pulley, O, turn the indicator to one side slightly until a perfect and uniform winding of the cord is obtained, which can always be easily secured. When pulley, O, is running, motion to the paper drum, B, is obtained by pushing in the swivel collar, U, to which the clutch pin is secured.

*When ready* to take diagrams, after placing the paper on the drum, B, it is necessary first to advance the drum away from its stop fully one-quarter inch, which can be done by turning with one hand the knurled top thumb

piece. While holding drum in this position, with the other hand push in gently the swivel collar, U, to start the paper drum in motion. The motion of the paper drum, B, can, at any time, be stopped, for removing diagrams taken and renewing the paper, by withdrawing swivel collar, U, or by turning top thumb piece, the latter method being preferable. The stopping of the paper drum will not affect the motion of the pulley, O, which will continue to revolve independently while the engine is in motion until the cord is disconnected.

Table of the sizes of pulleys required for use on above style indicator, for piston strokes of various lengths:

| Length of Stroke. | Diameter of Pulley. | Length of Stroke. | Diameter of Pulley. |
|---|---|---|---|
| 1 Foot | 1 Inch | 4 Feet | 4 Inches |
| 1½ Feet | 1½ Inches | 4½ " | 4½ " |
| 2 " | 2 " | 5 " | 5 " |
| 2½ " | 2½ " | 5½ " | 5½ " |
| 3 " | 3 " | 6 " | 6 " |
| 3½ " | 3½ " | | |

WITH SMALL DRUMS.

FIG. 381.

PRICES.

Tabor indicator, as shown, fully nickel-plated with 1½-inch diameter drum, one cyclinder spring, one boxwood scale, two straight cocks, 100 cards, two screw-drivers, one bottle porpoise oil, two wrenches, one extra drum spring, all enclosed in a substantial, well-finished black walnut box, with nickel-plated trimmings, each, $85.00.

Tabor indicator, as above, with Houghtaling Reducing motion, as shown in figure 380, each, $115.00.

One three-way cock, in place of two straight cocks, will be furnished, without extra charge, if called for.

With each outfit of indicators we furnish, without charge, Houghtaling's book on the *Steam Engine Indicator and its Appliances*, a valuable publication of 300 pages, describing the operation of the indicator on all classes of engines.

*For prices of parts and extras, see page 112.*

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GENERAL DESCRIPTON.

To meet the requirements for use on *excessive* high speeds, of a small compact, reliable indicator with smaller paper drum, and less range of pencil movement, so as to reduce the effects of the momentum of its rapidly moving parts to a minimum, we have designed, and now manufacture, this small-sized Tabor Steam Engine Indicator, Fig. 381. It is the same in construction, finish and general appearance as the instrument shown in Fig. 379, but of a *reduced size*. The diameter of its piston, and the multiplication of its pencil movement, 5 to 1, are the same as in the larger indicator, but the travel of the piston is less, and the paper drum is only 1½ inches in diameter by 2⅞ inches high. The body of the indicator is also reduced in length, which lessens the total weight of the complete instrument and adds to its symmetrical design.

We also make this indicator complete with the Houghtaling Reducing Motion, as shown in Fig. 380.

NAVY PATTERN.

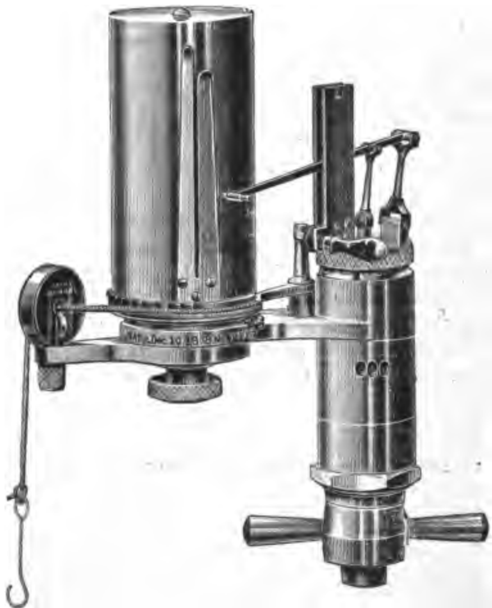

Fig. 382—Standard Size Indicator.

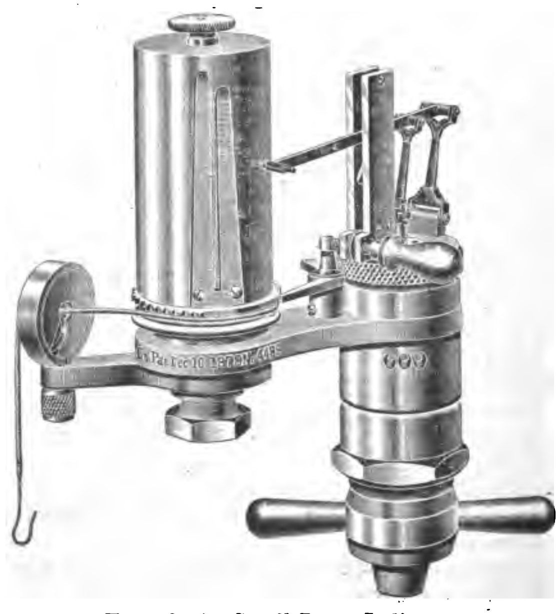

Fig. 382-A—Small Drum Indicator.

In our special Navy Pattern Indicator, which is used extensively in the United States, English, Russian and Japanese navies, we employ an improved device, by which the escaping steam from the indicator can be discharged away from the operator in any desired direction. This improved device consists of a chambered swivel ring fitting loosely around the body of the instrument into which, by means of holes drilled through the top, the steam that passes by the piston escapes. This ring has a series of holes drilled through it for the final escape of the steam to the atmosphere.

The special Navy Pattern Indicator, Fig. 382, is used on the main engines of battle ships, cruisers, monitors, etc., and has paper drum 2⅓₂ inches in diameter.

Fig. 382-A illustrates a smaller sized special Navy Pattern Indicator, in which are embodied all the qualities and improved features of the indicator shown in Fig 382. The paper drum on this indicator is only 1½ inches in diameter and 2⅞ inches high, and the reduced size enables it to be used in smaller space than is required for the larger instrument and for the highest speeds. This instrument is used largely on torpedo boats.

Either one of these instruments can be furnished complete with the Houghtaling Reducing Motion (see Fig. 380) if so called for in order.

*Prices on application.*

FITTED WITH HOUGHTALING REDUCING MOTION AND ELECTRIC ATTACHMENT.

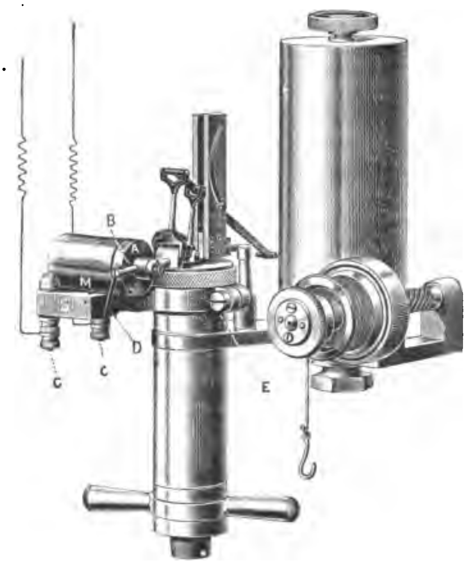


FIG. 386.

PRICES.

Tabor Indicator, as above, fully nickeled, with one cylinder spring, one boxwood scale, two straight cocks, one hundred cards two screw drivers, one bottle of porpoise oil, two wrenches, one extra drum spring, all enclosed in a substantial, well-finished black walnut box, with nickel-plated trimmings, each, $140.00.

Tabor Indicator, as above, but without the Houtaling Reducing Motion, each, $110.00.

One three-way cock in place of the two straight cocks will be furnished, without extra charge, if called for.

With each outfit of indicators we furnish, without charge, *Houghtaling's* book on the *Steam Engine Indicator and its Appliances*, a valuable publication of 300 pages, describing the operation of the indicator on all classes of engines.

*For prices of parts and extras, see page 112.*

DESCRIPTION OF ELECTRIC ATTACHMENT.

In making complete and reliable tests of steam power from any and all classes of engines, wherever it is necessary to use two or more Indicators for the purpose, it requires some convenient and rapid means of operating them so that all cards taken at any particular stroke of the engine will commence and leave off in the same interval of time. The cut represents a simple electrical attachment as it is applied to the Tabor Indicator for this purpose to enable the operator to produce diagrams from one or more Indicators simultaneously during the same stroke of the engines, and from any number of cylinders, by simply pressing a button arranged to close the electrical circuit.

The attachment consists of a magnet support, S, which is clamped to the body of the Indicator and held in place by the set screw, E. A magnet, M, is secured to the support, also binding screws C and spring D. An armature, A, is mounted on the rod B, and adjusted to coincide with the magnet M, and then secured to the rod B by the small set screw in the armature for that purpose. The rod B is screwed into the upright on the swivel plate of the Indicator, and any movement of the armature A produces a similar movement of the pencil toward or from the paper drum. The spring D is for the purpose of holding the armature within the field of the magnet before the current is established, and also to quickly release it when the current from the battery is broken.

The improved device is easily attached to or detached from the Indicator in a few seconds. By removing the cap that supports the pencil movement of the Indicator and slackening the set screw E of the support S, the attachment is readily removed. Its connection with the Indicator does not in any way interfere with the usual speedy and convenient means of adjusting the diagram paper to, or removing it from, the paper-holding drum, or the changing of a spring in the instrument. It can be used on either right-hand or left-hand Indicators with equal facility by reversing the

magnet support S and the magnet M, the latter being secured to its supporting shelf by two small screws. Any one of the well known batteries in the market (either dry or liquid) will be ample to operate a single Indicator where the circuit is short.

FITTED WITH DRUM STOP ATTACHMENT.

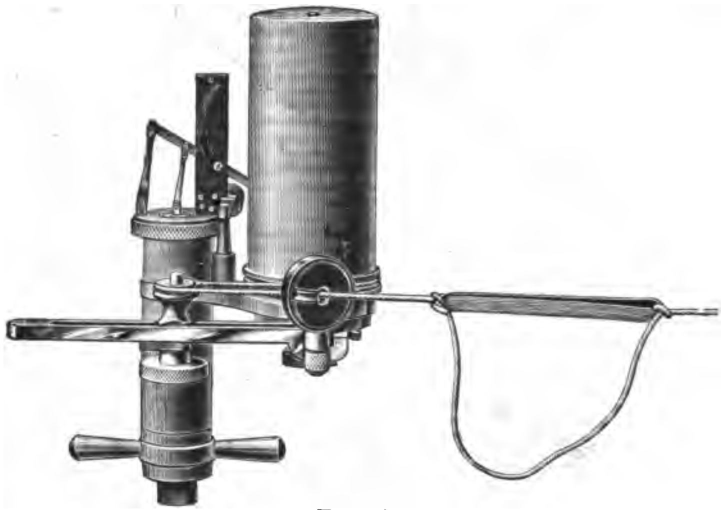

FIG. 387.

*Price of Drum Stop Attachment, $5.00 Each.*

DESCRIPTION.

This attachment is for the purpose of starting and stopping the Indicator paper drum at all times without unhooking the actuating cord. It consists of an arm attached to a part of the Indicator by a screw. A slide is adjustable on the arm, and upon it is mounted a cord pulley for directing the actuating cord around the paper drum of the Indicator. Said slide can be instantly secured in any desired position on the arm by the thumb nut and washer.

The *manner of connecting* and operating the attachment is as follows: The actuating cord from any ordinary form of reducing motion connected with the engine is passed around the cord pulley, thence on the paper drum of the Indicator. When the slide is at its inner position no motion will be transmitted to the paper drum, but by taking hold of the thumb nut and moving the slide outward on the arm, it will cause the paper drum to rotate back and forth in the usual way while taking a card. At any convenient position on the actuating cord there is superposed a rubber band for the purpose of taking care of any slack in the cord when the slide is at its extreme inner position and paper drum at rest, thus avoiding any unhooking of the actuating cord during the time of operating the Indicator when making tests.

## LAZY TONGS OR PANTOGRAPHS.

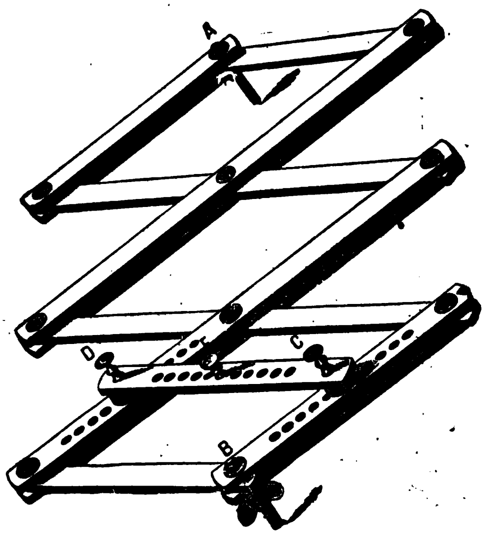


FIG. 388.

*Price $10.00 Each.*

There are various devices used to reduce engine strokes to conform to the travel of the drum of an Indicator not equipped with the reducing motion. The above cut, one-sixth actual size, is one of the appliances frequently used to obtain the necessary motion (on a reduced scale) between the paper drum and the engine cross-head. This device is pivoted at the end (B) by a stud and winged thumb nut to a block of wood or angle iron secured to the floor of the engine room, while the end (A) is fitted in a suitable piece secured to the cross-head of the engine. The actuating cord from the Indicator is attached to the cord pin (E) on the cross-bar (C D). This cross-bar may be moved in different positions with relation to the center (B) by changing the screws (C and D), and the cord-pin (E) must always be placed in a line with the centers (A and B). The position of the cross-bar (C D) in relation to (B) determines the length of travel of the cord-pin (E), and consequently the length of the diagram.

This Lazy Tongs can be used to obtain any desired reduction of motion of the engine piston, of various length strokes up to 72 inches.

ASHCROFT REDUCING WHEELS.

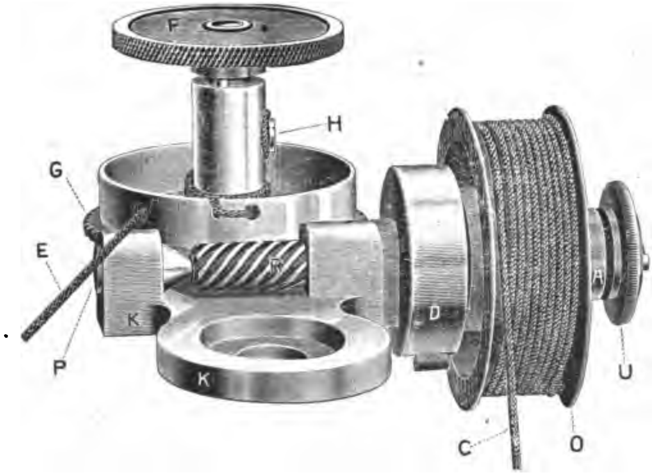


FIG. 389.

*Price, $25.00 Each.*

To ensure an accurate reduction of the stroke of an engine to the desired length of the Indicator diagram to be taken therefrom, a reliable reducing motion is essential. Various modifications of the pendulum lever, pantographs, and other combinations are employed to accomplish this result, often with accuracy when they are used under favorable conditions. The "wheel" has proved a much more reliable and satisfactory reducing motion than any of the other kinds, and during the last few years it has, to a great extent, superseded all other devices for the same purpose.

The illustration herewith represents an *independent* Reducing Wheel motion of our own design, so made that it can be applied not only to our own Tabor Indicators, but to some of the other Indicators now on the market. Its principle of operation, and instructions for its manipulation when in use, are practically the same as apply to the positive reducing motion forming a part of our Tabor Steam Engine Indicator, as shown in Fig. 380, page 9. This device can be secured directly to an Indicator, or it can be located at any convenient suitable position away from it and will work satisfactorily in either position.

DESCRIPTION.

The device consists of a base "K," with two standards for the bearings for the worm shaft "R." The base is extended to provide a support for the worm gear disc "G," to which the cord "E," from the Indicator paper drum, is secured in a manner as illustrated. A pulley "O," of suitable diameter for the stroke of the engine, is loosely mounted on the worm shaft "R," to

which pulley one end of the separate driving cord "C" is secured, the other end of the cord being connected either direct to the engine cross-head, to a standard bolted thereto, or to any other part of the engine having a coincident motion. From whatever point selected for attaching the cord, it is necessary that the cord run in a line practically parallel with the travel of the engine cross-head for a distance of at least the length of the engine stroke.

A small flat coil spring, located in the spring case "D," is connected to the pulley "O" by means of a disc (not shown in illustration), for the sole purpose of rewinding upon the pulley the slack cord that would otherwise occur during the inward stroke of the engine. When in operation the entire mechanism is returned to its normal position at the termination of the inner stroke of the engine at each revolution, by the action of the spring inside the paper drum of the Indicator. When ready to operate, and just before engaging the clutch by means of swivel collar "U," the knurled disc on top should be turned around slightly to advance the paper drum of the Indicator sufficiently to avoid the drum striking against its stop upon its return motion.

Reducing pulleys of 1-inch, 2-inch, and 3½-inch diameter are furnished with this Reducing Wheel. Special sizes of pulleys can be made to order.

For particulars of the required size of pulleys for different strokes of engines, see table on page 11.

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STRAIGHTWAY COCKS.

Fig. 390

Price..................$2.75 each.

THREE-WAY COCKS.

Fig. 391

Price, Brass...........$6.00 each.

Nickeled....... 7.00 "

CYLINDER SPRINGS

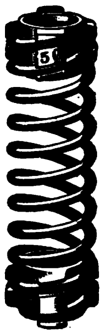


Fig. 393

Price........$5.00 each

| Scale of Springs | Maximum safe pressures to which they can be subjected. Lbs. Pressure per Sq. In. To 200 Rev. | To 300 Rev. |
|---|---|---|
| 8 | 10 | 6 |
| 10 | 15 | 10 |
| 12 | 20 | 15 |
| 16 | 28 | 22 |
| 20 | 40 | 32 |
| 24 | 48 | 40 |
| 30 | 70 | 58 |
| 32 | 75 | 62 |
| 40 | 95 | 80 |
| 48 | 112 | 95 |
| 50 | 120 | 100 |
| 60 | 140 | 115 |
| 64 | 152 | 125 |
| 80 | 180 | 145 |
| 100 | 200 | 160 |
| 120 | 240 | 195 |
| 150 | 290 | 250 |
| 200 | 375 | 330 |

ASCROFT
CARRYING PULLEYS


Fig. 394
Price........$2.50 each

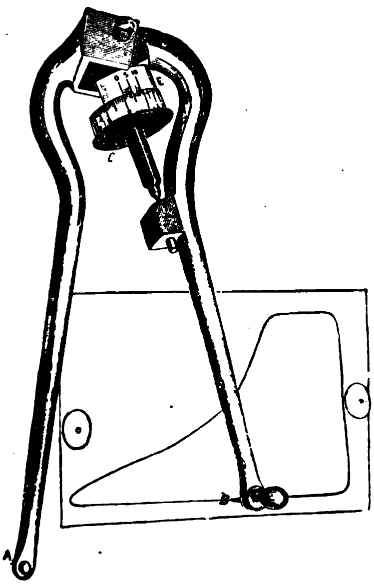
## TABOR STEAM ENGINE INDICATORS.

### PRICES FOR PARTS AND EXTRAS.

| | | |
|---|---|---|
| Steel Scales, 7 graduations | each | $1.50 |
| Nickeled Elbows | " | 2.50 |
| Double Carrying Pulleys | " | 3.00 |
| Parallel Rule | " | 7.00 |
| Metallic Cards | per 100 | .75 |
| Plain " | " " | .40 |
| Cord, warranted non-stretchable | per hank | .50 |
| Drum Spring | each | .40 |
| Houghtaling's book on the Steam Engine Indicator and Its Appliances | " | 2.00 |

## AMSLER PLANIMETERS.

FOR MEASURING THE AREAS OF CARDS FROM STEAM ENGINE INDICATORS.




GENERAL INSTRUCTIONS.

It is necessary first to make sure that the instrument is in good condition. The roller-wheel ought to play easily without touching the vernier. The pivots ought to turn very easily, but without dead motion or back-lash. The needle point ought to project but very little. The outside edge of the roller-wheel especially is very delicate, and will bear neither the least injury nor spot of rust upon its rolling surface. It is very necessary that the arms and tracer should not be bent, and that, if using No. 3, the sliding bar should be in its proper position. Care should also be taken to have a flat, even surface for the roller-wheel to travel upon.

Price....................$15.00 each.

*With Extended Arm.*

Price....................$30.00 each.

# COFFIN AVERAGERS OR PLANIMETERS.

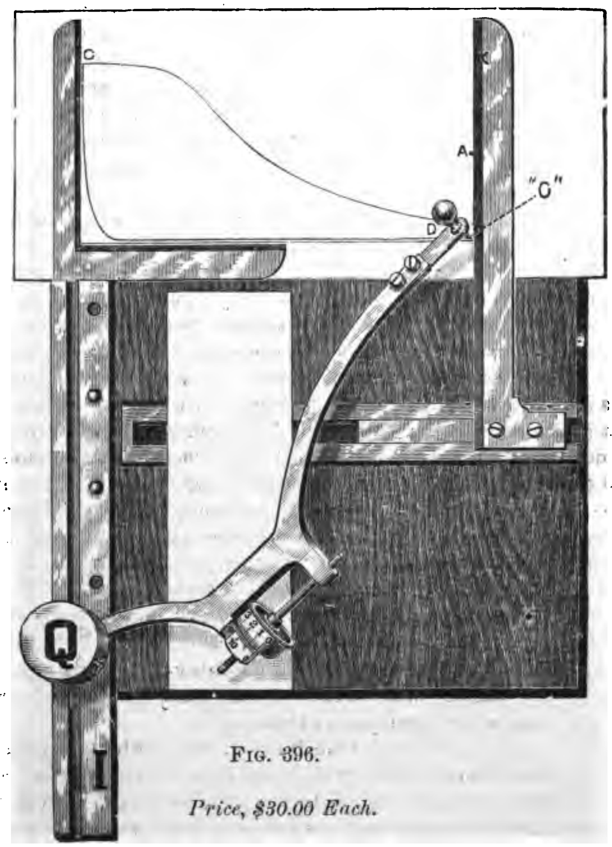



FIG. 396.

*Price, $30.00 Each.*

This instrument is a great saver of time in computing Indicator diagrams, as by its use both the areas and mean effective pressures are reliably and quickly ascertained without any mathematical calculations whatever. It is designed to measure the areas of irregular figures, and is operated by moving a tracer, with which it is fitted, over the line of diagram, recording the area upon a graduated wheel.

*In using* the Coffin Averager, the grooved metal plate, I, is first connected to the board upon which the apparatus is mounted, in the position shown in the cut, being held in place by a thumb screw applied from the back side. The indicator card is then placed under the clamps C and K, which may be sprung away from the board a sufficient amount to allow the card to be introduced, and the card is moved toward the left into such a position that the atmospheric line is near to and parallel with the lower

edge of the stationary clamp C, while the extreme left hand end of the diagram is even with the perpendicular edge of the clamp. The movable clamp K, which is fastened at the bottom to a sliding plate, is then moved toward the left, till the vertical beveled edge just touches the extreme right-hand end of the diagram. The diagram shown in the cut represents the proper location which should exist when these preliminary adjustments have been completed. The slide at the bottom of clamp K fits closely, so that the application of a slight pressure with the thumb or finger is required to displace it.

*The beam* of the instrument is next placed on the board, with the pin at the lower end resting in the groove I, and the weight Q applied to the top of the pin so as to keep it securely in place. The tracer O is moved to the right-hand end of the diagram and set at the point D, on the line of diagram, where the clamp K and the diagram touch each other. Here a slight indentation is made in the paper by pressing the finger on the top of the tracer, and this serves as a starting point. The graduated wheel is next turned so as to bring its zero mark to the zero mark on the vernier. The instrument is now ready for operation. The tracer O is carefully moved over the line of the diagram, in the direction of motion of the hands of a watch, and continued till a complete circuit is made and the tracer finally reaches the starting point D. Keeping the eye on the wheel, the tracer is now moved upward by sliding it along the edge of the clamp K, until the reading on the wheel returns to zero. Another light indentation is made on the paper to mark the new position which the tracer occupies. This point is represented at A in the cut. The instrument is now moved away, the clamp pushed back, and the distance between the two points D and A is measured with a scale corresponding to the number of the spring used in the Indicator. The distance thus found is the mean effective pressure, expressed in pounds per square inch of piston.

The *Coffin Averager* determines the desired result without computation but it may be used also for determining the area enclosed by the diagram This area is given by the reading on the graduated wheel, when the circuit of the diagram has been made and the tracer reaches the starting point, D. The wheel has fifteen main divisions, each of which represents one square inch of area. Each division has five subdivisions, each subdivision representing one fi th, or two-tenths, of a square inch of area. The vernier scale enables the subdivisions to be read to fiftieths, each of these fiftieths, therefor, representing two one hundredths of a square inch. Having obtained the area in this manner, the mean effective pressure can be computed therefore, if desired, by dividing the number of the spring representing the pressure per inch in height by the length of the diagram (inches) and multiplying the quotient by the area (square inches). In first placing the Indicator card under the clamps, care must be taken to have the ends of the diagram set a little away from the edge of the clamp, so as to allow for one half the diameter of the tracer, and to bring the center of the tracer over the center of the line of the diagram.

# The Steam Engine Indicator.

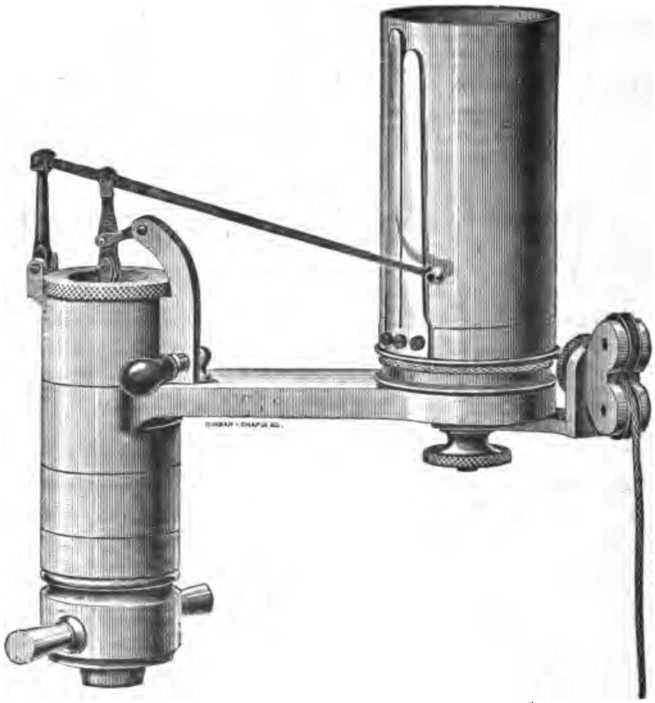
The degree of excellence to which steam engines of the present time have been brought is due more to the use of the indicator than to any other cause. A careful study of indicator diagrams taken under different conditions of load, pressure, etc., furnishes the only means of showing the action of steam in an engine, and o gaining a definite knowledge of the various changes of pressure that take place in the cylinder.

An indicator diagram is the result of two motions, namely: a horizontal movement of the paper in exact correspondence with the movement of the piston, and a vertical movement of the pencil in exact ratio to the pressure exerted in the cylinder of the engine. Consequently, it represents by its length, the stroke of the engine on a reduced scale, and by its height at any point, the pressure on the piston, at a corresponding point in the stroke. The shape of the diagram depends altogether upon the manner in which the steam is admited to and released from the cylinder of the engine. The variety of shapes given from different engines, and by the same engine under different circumstances, is almost endless, and it is in the intelligent and careful measurement of these that the true value of the indicator is found, and no one at the present day can claim to be a competent engineer who has not become familiar with the use of the indicator, and skillful in turning to practical advantage the varied information which it furnishes.

A diagram shows the pressure acting on one side of the piston only, during both the forward and return stroke, whereon all the changes of pressure may be properly located, stud ed and measured. To show the corresponding pressure on the other side of the piston, another diagram must be taken from the other end of the cylinder. When the three-way cock is used, the diagrams from both ends are usually taken on the same paper.

# The Crosby Steam Engine Indicator.

**PATENTED.**

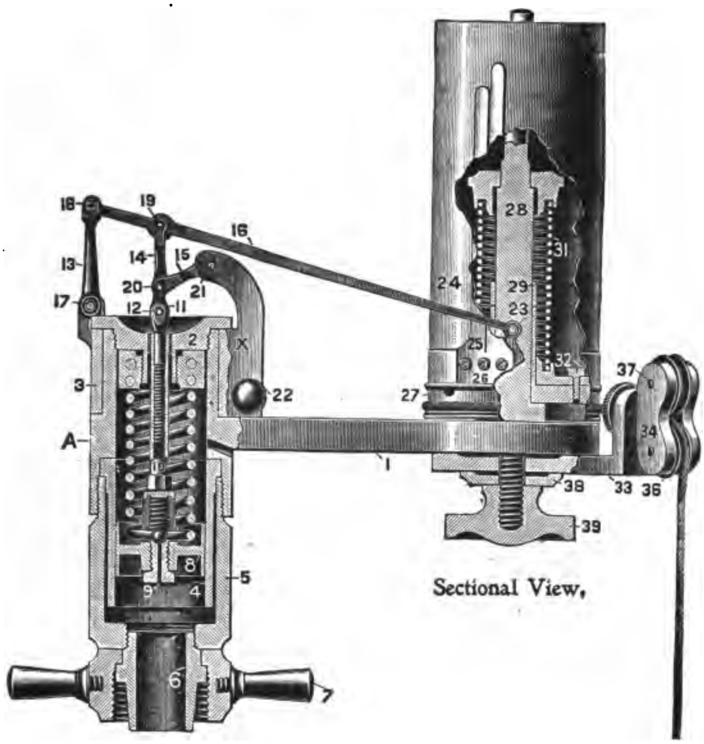


The Crosby Steam Engine Indicator is designed to meet the requirements of modern steam engineering practice. The high-speed system of construction in steam engines which greatly prevails to-day, renders the older type of indicator well-nigh useless. Many details which gave little trouble at low speeds, cause errors under the present requirments which seriously affect the results.

To obtain trustworthy results on high-speed engines, an indicator must have extreme lightness, a nice adjustment of all the moving parts, and fine workmanship; to these *indispensable* qualities should be added simplicity of construction and convenience of manipulation. All these are found in the Crosby Indicator.

The Crosby Indicator, in a special design, is made to indicate extremely high pressures. Instruments of this design have been used with perfect success in the testing of ordnance, measuring hydraulic pressures, and indicating gas engines. For these purposes a specially strong pencil mechanism and pencil lever are used.

# Description of the Crosby Steam Engine Indicator.




Sectional View.

The illustration shows the design and arrangement of the parts of the Crosby Steam Engine Indicator.

Part 4 is the cylinder proper, in which the movement of the piston takes place. It is made of a special alloy, exactly suited to the varying temperatures to which it is subjected, and secures to the piston the same freedom of movement with high pressure steam as with low; and as its bottom end is free and out of contact with all other parts, its longitudinal expansion or contraction is unimpeded and no distortion can possibly take place.

Between the parts 4 and 5 is an annular chamber, which serves as a steam jacket; it will always be filled with steam of nearly the same temperature as tha in the cylinder.

*The Piston*, 8, is formed from a solid piece of the finest tool steel. Its shell is made as thin as possible consistent with proper strength. It

is hardened to prevent any reduction of its area by wearing, then ground and lapped to fit (to the ten thousandth part of an inch) a cylindrical gage of standard size. Shallow channels in its outer surface provide a steam packing, and the moisture and oil which they retain act as lubricants, and prevent undue leakage by the piston. The transverse web near its centre supports a central socket, which projects both upward and downward; the upper part is threaded inside to receive the lower end of the piston-rod; the upper edge of this socket is formed to fit nicely into a circular channel in the under side of the shoulder of the piston-rod, when they are properly connected. It has a longitudinal slot which permits the ball bearing on the end of the spring to drop to a concave bearing in the upper end of the piston-screw 9, which is closely threaded into the lower part of the socket; the head of this screw is hexagonal and may be turned with the hollow wrench which accompanies the indicator.

*The Piston-rod*, 10, is of steel and is made hollow for lightness. Its lower end is threaded to screw into the upper socket of the piston. Above the threaded portion is a shoulder having in its under side a circular channel formed to receive the upper edge of the socket, when these parts are connected together. When making this connection the piston-rod should be screwed into the socket as far as it will go, that is, until the upper edge of the socket is brought firmly against the bottom of the channel in the piston-rod. This is very important, as it insures a correct alignment of the parts, and a free movement of the piston within the cylinder.

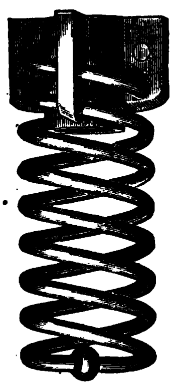
*The Swivel Head*, 11, is threaded on its lower half to screw into the piston-rod more or less according to the required height of the atmospheric line on the diagram. Its head is pivoted to the piston-rod link of the pencil mechanism.

*The Cap*, 2, screws into the top of the cylinder and holds the sleeve and all connected parts in place. Its central hole is furnished with a hardened steel bushing which forms a durable and sure guide to the piston-rod. On its under side are two threaded portions. The lower and smaller projection is screw-threaded outside to engage with the like threads in the head of the spring and hold it firmly in place. The upper and larger projection is screw-threaded on its lower half to engage with the light threads inside the cylinder; the upper half of this larger projection,—being the smooth vertical portion,—is accurately fitted into a corresponding recess in the top of the cylinder, and forms thereby a guide by which all the moving parts are adjusted and kept in correct alignment, which is very important, and is impossible to secure by the use of screw threads alone.

*The Sleeve*, 3, surrounds the upper part of the cylinder, and supports the pencil mechanism. It turns around freely, and is held in place by the cap. The handle for adjusting the pencil point is threaded through the arm and in contact with a stop-screw in the plate, 1, may be delicately adjusted to the surface of the paper on the drum. It is made of hard wood in two sections; the inner one may be used as a lock-nut to maintain the adjustment.

*The Pencil Mechanism*, is designed to afford sufficient strength and steadiness of movement, with the utmost lightness; thereby eliminating as far as possible the effect of momentum, which is especially troublesome in high speed work. Its fundamental kinematic principle is that of the pantograph. The fulcrum of the mechanism as a whole, the point of attachment to the piston-rod, and the pencil point are always in a straight line. This gives to the pencil point a movement exactly parallel with that of the piston. The movement of the spring throughout its range bears a constant ratio to the force applied and the amount of this movement is multiplied six times at the pencil point. The pencil lever, links and pins are all made of hardened steel; the latter,—slightly tapering,— are ground and lapped to fit accurately, without perceptible friction or lost motion.

*Springs*. In order to obtain a correct diagram, the movement of the pencil of the indicator must be exactly proportional to the pressure per square inch on the piston of the steam engine at every point of the stroke; and the velocity of the surface of the drum must bear at every instant a constant ratio to the velocity of the piston. These two essential conditions have been attained to a greater degree of exactness in the Crosby Indicator than in any other make, by a very ingenious construction and nice adaptation of both its piston and drum springs.



*The Piston Spring* is of unique and ingenious design, being made of a single piece of the finest spring steel wire, wound from the middle into a double coil, the spiral ends of which are screwed into a brass head having four radial wings with spirally drilled holes to receive and hold them securely in place.

Adjustment is made by screwing them into the head more or less until exactly the right strength of spring is obtained, when they are there firmly fixed. This method of fastening and adjusting removes all danger of loosening coils, and obviates all necessity for grinding the wires — a practice fatal to accuracy in indicator springs.

At the bottom of the spring — in which lightness is of great importance, it being the part subject to the greatest movement — is a small

steel bead, firmly attached to the wire. This takes the place of the heavy brass foot used in other indicators, and reduces the inertia and momentum at this point to a minimum, whereby a great improvement is effected. This bead has its bearing in the centre of the piston, and in connection with the lower end of the piston-rod and the upper end of the piston-screw, 9, (both of which are concaved to fit) it forms a ball and socket joint, which allows the spring to yield to pressure from any direction without causing the piston to bind in the cylinder, which is sure to occur when the spring and piston are rigidly united. It is of extreme importance that the spring be so designed that any lateral movement it may receive when being compressed shall not be communicated to the piston and cause errors in the diagram.

*The Testing of the Spring.* The rating or measurement of the springs, both in vacuum and in pressure, is determined with great care and accuracy by special apparatus. The vacuum test is made by a powerful vacuum pump to which is connected a mercury column marked in inches. The pressure test is by the direct action of the steam in the cylinder of the indicator and in a mercury column simultaneously operating with a capacity of three hundred pounds pressure per square inch. Suitable and ingenious electrical apparatus is so combined with these mercury columns that the ordinary division in inches of vacuum and in pounds pressure respectively are automatically marked on the test card on the indicator drum as the test of the spring proceeds. Each spring is tested in pressure to twice the capacity marked on the same. This method of testing pressure springs has been in use for several years and has been demonstrated to be the best system for accuracy.

*The Drum Spring*, 31, in the Crosby Indicator is a short spiral spring. In every other make a long volute spring is used.

It is obvious from the large contact surfaces of a long volute spring that its friction would be greater than that of a short, open spiral form; also, that in a spring of each kind, for a given amount of compression, —as in the movement of an indicator drum—the recoil would be greater and expended more quickly in the spiral than in the volute form.

If the conditions under which the drum spring operates be considered, it will readily be seen, that at the beginning of the stroke, when the cord has all the resistance of the drum and spring to overcome, the latter should offer less resistance than at any other time; in the beginning of the stroke in the opposite direction, however, when the spring has to overcome the inertia and friction of the drum, its energy or recoil should be greatest.

These conditions are fully met in the Crosby Indicator; its drum spring being a short spiral having no friction, has a quick recoil, and is

scientifically proportioned to the work it has to do. At the beginning of the forward stroke it offers to the cord only a very slight resistance which gradually increases by compression, until at the end its maximum is reached. At the beginning of the stroke in the other direction its strength and recoil are greatest at the moment when both are most needed, and gradually decrease until the minimum is reached at the end of the stroke. Thus by a most ingenious balancing of opposing forces, a nearly uniform stress on the cord is maintained throughout each revolution of the engine,

*The Drum*, 24, and its appurtenances, except the drum spring, are similar in design and function to like parts of other indicators and need not be particularly described. All the moving parts are designed to secure sufficient strength with the utmost lightness, by which the effect of inertia and momentum is reduced to the least possible amount.

The Crosby Indicator is made with a drum one and one-half inches in diameter, this being the correct size for high speed work, and answering equally well for low speeds. If, however, the indicator is to be used only for low speeds and a longer diagram is preferred, it can be furnished with a two-inch drum.

All Crosby Indicators which are numbered above 3737 are changeable from right-hand to left-hand instruments if occasion requires.

From the design of the Crosby Indicator as above set forth — the conformation and purpose of its several parts — it will be seen that every opportunity to improve the instrument has been taken; add to this the fact that only the most skillful workmen of long training in the art are employed, and that every part is made to a standard size by modern specialized machinery, with tools perfectly adapted to their work, and it will be admitted that the proper means have been taken to produce a first-class indicator. We believe this object has been accomplished and that the Crosby Indicator is capable of yielding more accurate results than have hitherto been attainable with any other instrument.

The Crosby Indicator is the standard instrument in all the principal navies and technical schools in Europe. For export, when so required, the springs and scales are graduated according to the metric system, and threads are cut to English standard. All foreign orders or inquiries should be addressed to our London Office,

75 QUEEN VICTORIA STREET, LONDON, ENGLAND.

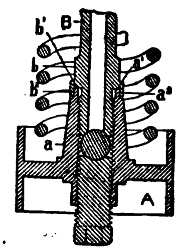
# How to Handle and Take Care of the Crosby Indicator.

The indicator is a delicate instrument, and in order to secure good results from its use, it must be handled with care and be kept in good order.

To Remove the Piston and Spring, unscrew the cap; then take hold of the sleeve and lift all the connected parts free from the cylinder. This gives access to all the parts to clean and oil them.

Never remove the pins or screws from the joints of the pencil movement, but keep them well oiled.

Important. In the under side of the shoulder of the piston-rod *B*, is a circular channel formed to receive the upper edge of the slotted socket of the piston *A*. Whenever it is desirable to connect the piston-rod with the piston, either in the process of attaching a spring, or for the purpose of testing the freedom of movement of the piston in the cylinder without a spring, BE SURE *to screw the piston-rod into the socket as far as it will go*; that is, until the upper end of the socket, $a^1$, is brought firmly against the bottom of the channel, $b^2$, in the piston-rod. This insures a perfectly central alignment of the parts and therefore a perfectly free movement of the piston within the cylinder.




To Attach a Spring. Hold the hollow wrench in an inverted position and insert the piston-rod until its hexagonal part engages the wrench; then with the spring inverted, insert the combined wrench and piston-rod until the head of the spring rests in the concaved end of the latter; then invert the piston and pass the transverse wire at the bottom of the spring through the slot until the threads at the bottom of the piston-rod engage those inside the socket of the piston, and with the wrench screw it in as far as it will go; that is, until the upper edge of the socket is in contact with the bottom of the channel in the shoulder of the piston-rod. The piston screw should be loosened slightly before this last operation and afterwards set up against the head lightly, to provide against any lost motion, yet not so as to make it rigid. Next, hold the sleeve and cap in an upright position — so that the pencil lever will drop to its lowest point — and engage the threads of the swivel head with those inside the piston-rod and screw it up until the threads on the

lower projection of the cap engage those in the spring head, and continue the process until the latter is screwed firmly up against the cap. Then, letting the cap go free and holding only by the sleeve, continue to turn the piston (together with its connections) until the top of the piston-rod is flush with the shoulder on the swivel head.

The piston and its connections may now be inserted in the cylinder and the cap screwed down, which will carry all parts into their proper places.

To detach a spring simply reverse this process.

To Change the Location of the Atmospheric Line of the Diagram. First, unscrew the cap and lift the sleeve, with its connections, from the cylinder; then — holding the sleeve with the left hand — with the right hand turn the piston and connected parts towards the left, and the pencil point will be raised, or to the right and it will be lowered. One complete revolution of the piston will raise or lower the pencil point ⅛ inch and this should be the guide for whatever amount of elevation or depression of the atmospheric line is needed.

To Change to a Left-Hand Instrument. If it is desired to make this change; First, remove the drum by a straight upward pull; then, with a screw driver remove the steel top screw in the drum base, and screw it into the vacant hole marked *L*: next, *reverse* the position of the adjusting handle in the arm; also, the position of the metallic point in the pencil lever; then replace the drum and the change from right to left will be completed.

This applies to all indicators numbered above 3737.

*The tension on the drum spring* may be increased or diminished according to the speed of the engine on which the instrument is to be used, as follows: Remove the drum by a straight upward pull; then raise the *head* of the spring *above* the *square* part of the spindle and turn it to the right for more or to the left for less tension, as required; then replace the head on the spindle.

Before attaching the indicator to an engine, be sure to *blow steam freely through pipes and cock* to remove any particle of dust or grit that may have lodged in them.

After using the indicator it should be carefully wiped and oiled.

For this purpose it is not often neccessary to disturb the paper drum, but the cylinder cap should be unscrewed and all the connected parts lifted out; then the piston, piston-rod and spring should be detached and all carefully wiped with cloth or tissue paper until perfectly dry, then slightly oiled with a lubricant of good quality; the inside of the cylinder should also be oiled. After this is done the piston and piston-rod

should be replaced in the cylinder, but the spring should be kept on its stud in the box when the instrument is not in use. This box should be kept in a dry place, locked, and the key in the owner's pocket.

After the indicator has laid unused for any length of time the oil used at its last cleaning may have become gritty or gummy, and should be wiped off with a soft cloth or tissue paper saturated with naphtha or benzine, and freshly oiled before using it again. This keeps the instrument in prime condition and insures the best results from its use. An occasional naphtha bath is good for an indicator, as it thoroughly cleanses every part.

If any grit or other obstruction gets into the cylinder it will seriously affect the diagram and lead to bad results. It is not difficult to detect such trouble and it should be remedied at once by taking out the piston, detaching the parts and cleaning them as above described, when the disturbing cause will generally be removed.

It is essential to know whether or not the indicator is in good condition for use; especially to know that the piston has perfect freedom of motion and is unobstructed by undue friction. To test this successfully, detach the spring and afterwards replace the piston and piston-rod in their usual position, then holding the indicator in an upright position by the cylinder in the left hand, raise the pencil arm to its highest point with the right hand and let it drop; it should freely descend to its lowest point *The inner walls of the cylinder should be frequently lubricated.* The pencil should always have a smooth fine point; for this purpose a fine file is the best instrument to use.

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The superior qualities of the *Crosby Steam Engine Indicator* were duly recognized at the Paris Exposition of 1889; at the Columbia Exposition in 1893; at the Cotton States and International Exposition at Atlanta in 1895, and at the Russian Exposition held at Nijni Novgorod in 1896, where it received the highest awards.

Its special features are fully protected by letters patent in the United States and Great Britain.

A report of indicator tests made at the Brooklyn Navy Yard, now on file in the Engineer-in-Chief's office at Washington, D. C., shows the great superiority of the Crosby Indicator over that of all others.

The Crosby Indicator is approved and adopted by the United States Government. It is the standard in nearly all the great Electric Light and Power Stations of the United States. It has been approved and adopted by the principal navies, the government shipyards, and the most eminent technical schools of the world.

# Crosby Steam Engine Indicator.

PATENTED.


The above cut shows the Crosby Steam Engine Indicator provided with a detent attachment for locomotive use.

Important improvements have been made in this instrument which place it far in advance of any other instrument of its kind. In its construction the use of special tools, and a careful selection of materials peculiarly adapted to its different parts and their uses, have contributed to the perfection of this instrument, so that in competent hands it is capable of yielding results accurate to a degree hitherto unattainable.

We solicit the closest inspection and criticism.

Price on application.

# Three-Way Cock.

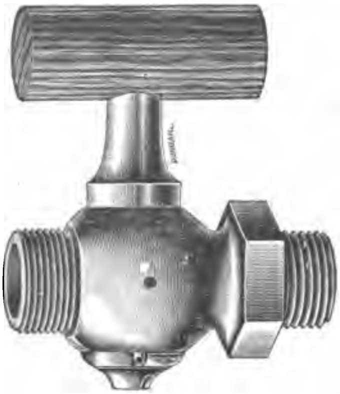
This cock is made of gun metal and nickel plated. It provides a large passage, having a turn of a long radius, thus making the loss of pressure from friction as small as possible.

It is threaded for a one-half inch pipe at one end and has a slip joint at the other to provide for the expansion of the pipe when heated.

The indicator connection is made to fit the coupling of the Crosby indicator. It will be modified to fit the coupling of any other indicator when so ordered.

For an Ammonia indicator this cock is made of steel.

Price, Nickel-Plated. (List), . . . . $7.00.
" Steel, on application.



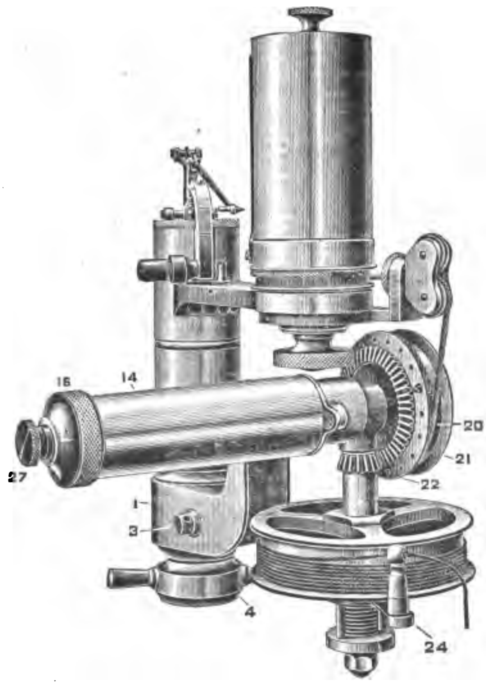
# Straight Cock.

These cocks are made of gun metal and nickel plated for the steam engine indicator; of steel for ammonia indicators.

Price, Nickel-Plated, (List), . . $3.00
" Steel, on application.

# Crosby Reducing Wheel.

**PATENT APPLIED FOR.**




**This cut shows the Crosby Indicator attached.**

The Crosby Reducing Wheel is attached directly to the cylinder cock of the steam engine and has connected to it the steam engine indicator which it is to serve; thus it forms a base or support for the latter and receives all the strains and shocks in the operations of the engine, to the relief of the indicator. All its parts are designed and constructed for strength, accuracy and durability. Its bearings are not only nicely adjusted but are made comparatively frictionless by the introduction of minute balls running in hardened tool steel bearings, affording lightness and freedom of movement. It has a hellical spring which is more active in its purpose than the volute spring in common use, this being a very essential feature for accurate results on high speed engines. The cord

pulley is horizontal to allow the cord leading to the engine crosshead to take any direction the circumstances may require without regard to the position of the indicator.

Whenever the reducing wheel is to be attached to a vertical engine, an elbow nipple is provided which will allow the cord pulley to travel in the proper plane for guiding it to the crosshead of the engine, with the indicator in an upright position as usual.

Special tools have been provided for making it, so that like parts are interchangeable, and when worn or destroyed others can be easily substituted in repairs; in other words, everything has been done so far as possible to make the instrument in all respects as excellent for its purpose as has been done in regard to the Crosby Indicator.

It is adapted to receive any steam engine indicator or indicator cock by means of interchangeable bushings; and by a series of speed pulleys to all steam engines having strokes between the limits of ten inches and seventy-two inches.

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# Directions for Operating the Crosby Reducing Wheel.

## ATTACHMENT.

Attach it directly to the cylinder cock of the steam engine by means of the union 4 of the standard 1. Connect the indicator to the standard 1 with the paper drum standing over the spring tube 14, and the indicator guide pulley in a proper position over the speed pulley 20.

## TO ADJUST THE CORD GUIDE.

Loosen the cord guide 24 by means of the screw beneath the cord pulley and move it around to the proper position for the cord to pass directly through to the crosshead of the engine; then tighten it in place.

## TO TAKE UP THE TENSION SPRING.

Release the thumb screw 27 in the end of the shaft within the spring tube 14; withdraw the knurled spring head 16 from its square end and turn it one or more squares as may be desired.

## TO ADJUST THE SPEED PULLEY.

Remove the aluminum disk 21 holding the speed pulley 20 in place on the gear shaft; place thereon the speed pulley desired; replace the disk and screw it up firmly with the fingers.

## TO ATTACH THE INDICATOR CORD.

Adjust the indicator cord one turn around the speed pulley 20, passing the end through a convenient hole in the aluminum plate 22, and secure it by a knot. Care should be taken not to leave a loose end of the cord to catch in the gears.

## WHEN USED WITH OTHER INDICATORS.

Loosen the bolt 3 in the side of the standard 1 where it is attached to the cylinder cock of the steam engine; remove the bushing and insert another fitted to the indicator to be used.

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# IMPORTANT SUGGESTIONS.

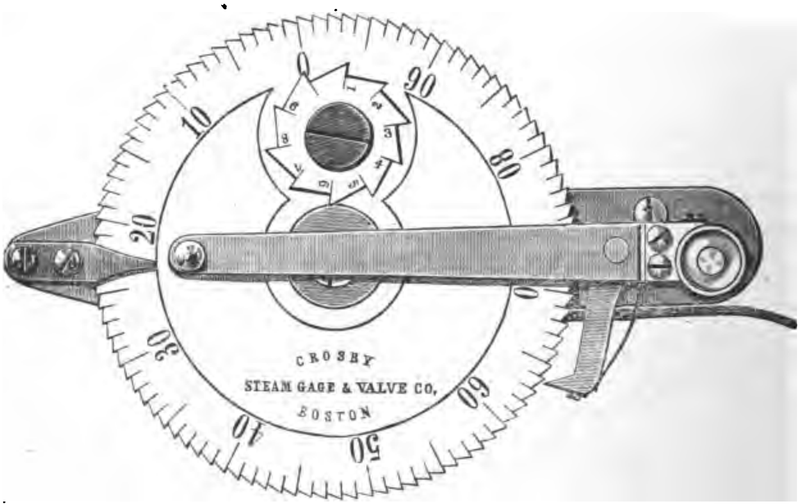
**In all cases the indicator cord should be of the right length to prevent the paper drum from recoiling against its stop; and before attaching it to the crosshead of the engine it should be drawn out its full length to ascertain whether or not the cords on the indicator and reducing wheel have been properly adjusted.**

**All the working parts must be kept well oiled.**

Price, . . . . . . $25.00

Send for discount.

# Locomotive Counter.




The above cut illustrates our locomotive counter. It is designed particularly for use on locomotives and high-speed engines, and is a valuable auxiliary to the steam engine indicator. The arm which moves the ratchet is connected by a cord with some reciprocating part of the engine, or with the drum motion, so as to give it about 1½ inches swing back and forth during each revolution of the shaft. It is provided with a convenient starting and stopping device, so that it can be made to begin or stop counting at any instant.

Price, . . . . . . . . . . . $25.00

Send for discount.

# Sargent's Electrical Attachment.

## For Steam Engine Indicators.

PATENTED.

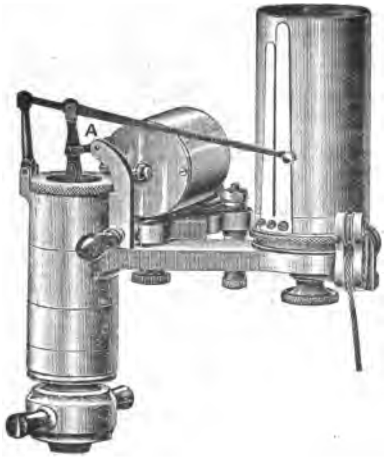



Fig. 1.

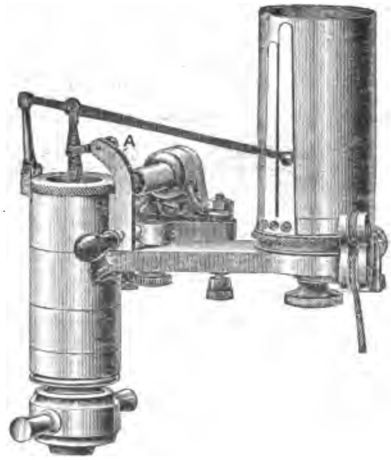



Fig. 2.

In making elaborate tests of power plants, it has heretofore been neccessary to employ as many assistants as there were indicators used, but the difficulty of securing simultaneous action on their part is so great that satisfactory work is rarely to be obtained, and more certain means to that end are now considered necessary.

Mr. Frederick Sargent, M. E., invented and patented an electrical device applicable to an indicator, by means of which any number of instruments can be operated and diagrams taken at the same instant of time, simply by closing an electric circuit.

We are the sole manufacturers of the Sargent device under United States and English Letters Patent assigned to us. As this invention and these patents are fundamental, in self protection we are obliged to warn the public against the use of any device which performs a similar duty, as such is an infringement.

Believing in the great importance of this invention as an aid to accurate results in indicator work, we confidently offer it to users of the Crosby Steam Engine Indicator as a valuable addition to the engineer's equipment.

Figure 1 shows a Crosby indicator fitted with a Sargent Electrical Attachment. Figure 2 shows a Crosby indicator fitted with a Circuit Closer.

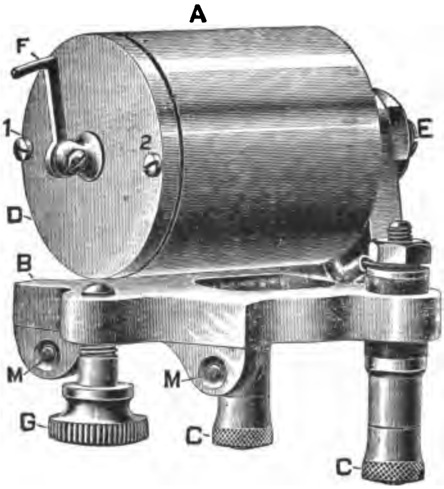



Fig. 3.

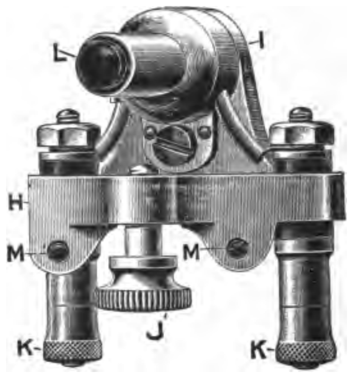



Fig. 4.

# Description.

Figure 3 represents Sargent's Electrical Attachment and consists of an electro magnet, *A*, which is supported by a bracket, *B*, which also secures it to the indicator plate. Binding posts, *C*, *C*, are attached to the same bracket. The armature *D* is opposed to the magnet by a spiral spring in the centre of the coil, the tension of which is adjustable by means of the screw *E*, at the back of the magnet. The movement of the armature outwardly is limited by two screws, 1 and 2. To the armature is secured a small latch or hook, *F*, which is free to work vertically and engage with a screw-eye inserted in the arm *A*, Figure 1. The thumb-screw *G* is for fastening the attachment to the plate of an indicator through a hole therein.

Figure 4 represents the Circuit Closer, and is designed to operate the electrically connected indicators, by closing the circuit through them, when the stylus or marking point is put against the paper on the drum of the indicator, to which it is attached. This enables the engineer making the test to control one of the indicators directly by hand—a feature often desirable—and by its use one Sargent attachment is dispensed with.

It consists of a bracket, *H*, with a tubular projection, *I*, fastened to it which contains the circuit closing mechanism. It is attached to the indicator plate by the thrumb-screw *J*, in precisely the same way that the magnets are to the other indicators, and is electrically connected in the same manner through the binding posts *K*, *K*.

# Directions for Connecting Sargent's Electrical Attachment and the Circuit Closer to Crosby Indicators.

## TO ATTACH SARGENT'S ELECTRICAL ATTACHMENT.

To get the position of the hole in the frame of the indicator, take out the screw *G* (Fig. 3), and place the bracket holding the magnet against the plate of the indicator, so that the hook *F* (Fig. 3), when placed horizontally will point to the middle of the arm *A* (Fig. 1); then scribe through the screw-hole its location upon the plate of the indicator; remove the attachment and drill a hole where marked that will allow the screw *G* (Fig. 3) to pass through it. Screw the attachment to the plate and adjust it so that there will be no looseness, turning by the screws *M M* (Figs. 3 and 4), setting them up gently.

Drop the hook *F* (Fig. 3) to a horizontal position and bring the arm *A* (Fig 1) up to its working position and mark on it the centre of the hole to be drilled for the screw-eye. This hole should be so drilled that the latch will stand level with the plate when in use. The size of the hole may be determined from the screw-eye furnished.

## TO ATTACH THE CIRCUIT CLOSER.

The position of the hole in the indicator plate for attaching the Circuit Closer, Figure 4, is determined in the same manner as for the electro magnet, taking care that the button *L* (Fig. 4) impinges the centre of the arm *A* (Fig. 1) when the sleeve is turned into the correct position for use.

The sleeve handle of the indicator is unscrewed far enough to allow the button *L* (Fig. 4) in the end of the projection *I* to go in as far as it will, then the marking point must be adjusted until it makes the desired tracing on the paper.

## TO OPERATE SARGENT'S ELECTRICAL ATTACHMENT AND CIRCUIT CLOSER.

For the purpose of illustrating the manner of operating the attachment, assume that it is desirable to procure simultaneous diagrams from a compound engine, taking cards from the ends of each cylinder. Attach the indicators to the engine and arrange the drum motion in the usual manner. On each indicator secure the electrical attachment to its plate by means of screw *G*, as above described. Make the connection

with the battery, having all of the several magnets and the circuit closer in series. Place the paper upon the drum and bring the pencil arm into such a position as will allow the latch $F$ to drop into the screw-eye before mentioned.

Press the armature firmly against the magnet and adjust the marking point to the paper in the usual manner. The sleeve handle must be unscrewed enough to allow the full operation of the armature. The circuit should be closed and the armature tension springs adjusted, so that the connected attachments will work simultaneously. Everything should now be in readiness to take diagrams. Connect the drum motions, open the indicator cocks, and as soon as desirable close the circuit, and instantly all of the pencils will be brought against the papers and will remain there as long as the circuit is kept closed.

In order to put on new papers, disengage the drum motions, lift the latch and swing the pencil arm out of the way.

### THE ELECTRIC BATTERY.

The amount of battery power required will vary with circumstances and will range from one to two or more cells of a No. 2 Sampson battery, or its equivalent.

The battery for operating the attachments is enclosed in a neat hardwood box with a suitable handle for carrying it, and is sealed so as to prevent slopping. It is very compact and portable, being at the same time extremely active, long lived and especially adapted to open circuit work.

The connections to the indicator attachments can be made with the battery without opening the box, the binding posts being on the outside.

This battery, with a quantity of suitable wire for making connections, is furnished with the attachment.

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## PRICES.

| | |
|---|---|
| Sargent's Electrical Attachment, . . . . . . . . | $25.00 |
| Circuit Closer, . . . . . . . . . . . . | 15.00 |
| A box containing two cells of a powerful battery, 100 feet of well insulated wire, and one pair of side cutting pliers, | 10.00 |

*Liberal discounts from the above prices.*

# Amsler's Planimeter.

The Planimeter is used to measure the area of any plane surface, whatever the outline may be. Persons who do not understand mathematics are easily able to use it and with a little practice in following the lines of the surface are able to arrive at accurate results much more quickly and accurately than a skillful mathematician employing ordinary arithmetical calculations.

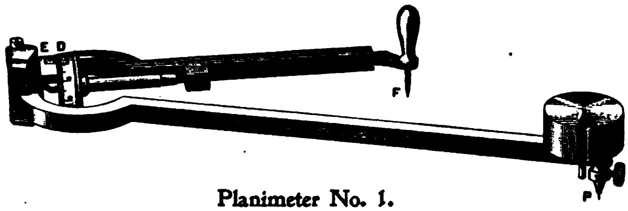
These instruments are manufactured expressly to our order in Europe and are nearer perfection in design, construction and finish than any other make. As now made, the roller-wheel and vernier are of celluloid, which makes their figures and graduations very clear and legible.

## PRICES.

| | |
|---|---|
| No. 1 Planimeter, with roller-wheel and vernier, . . . | $20.00 |
| No. 2 Planimeter, with counting disc, roller-wheel and vernier, | 25.00 |
| No. 3 Planimeter, with counting disc, roller-wheel, vernier and adjustable arm, . . . . . . . . . . | 30.00 |

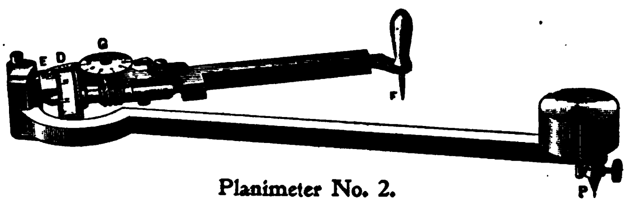
# Description of Amsler's Planimeter and its Recording Mechanism.

The Planimeter, in general terms, consists of two metallic arms or bars hinged together at one end. One arm carries a needle-point at its free end and acts as a pivot for the instrument. The other arm carries a tracer point with which to trace the outline of any figure or diagram to be measured. Near the hinge is a roller-wheel on which the instrument moves carrying a disc graduated to record the area traced about by the point.



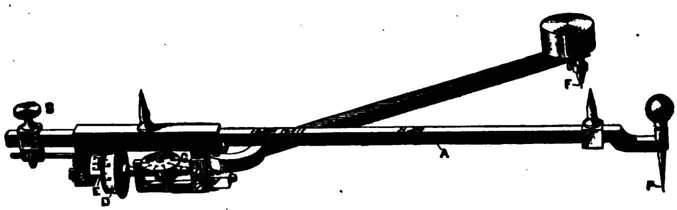

Planimeter No. 1.

No. 1 represents the Planimeter in its simplest form, as designed to measure areas in square inches and decimals of a square inch; it has but one wheel, the figures on which represent units, the intermediate graduations tenths, and the vernier gives the hundredths. One complete revolution of the roller-wheel represents an area of ten square inches measured and is its normal limit of measurement, but larger areas may be measured by adding *ten units* to the reading for *each complete revolution* of the roller-wheel.




Planimeter No. 2.

No. 2 represents the same instrument with the addition of the counting disc *G*, the figures on which represent tens and mark complete revolutions of the roller-wheel. By this means larger areas can be measured with facility, and the trouble of adding one or more tens is avoided.




Planimeter No. 3.

No. 3 Planimeter differs somewhat in design from the two previously described, but has the same recording mechanism as the No. 2.

It is capable of measuring larger areas, and, by means of an adjustable arm, giving the results in various denominations of value, such as square decimetres, square feet and square inches, also of giving the *average height* of an indicator diagram in fortieths of an inch, which makes it a very useful instrument in connection with steam engine indicator work.

# The Recording Mechanism Explained.

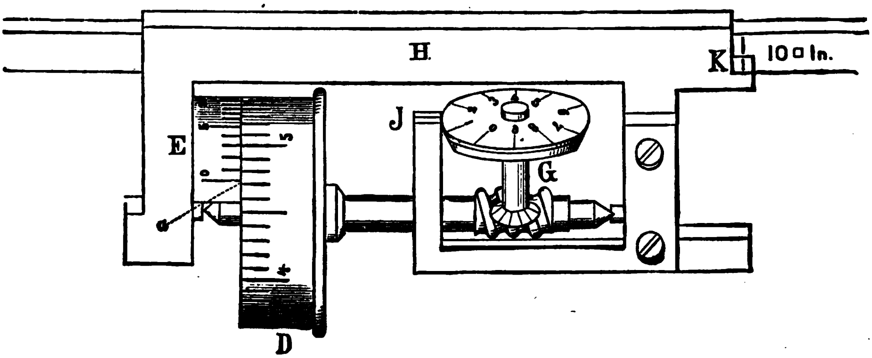



Fig. 1.

Fig. 1 shows in detail the recording mechanism of a No. 3 Planimeter from which the method of reading results of measurements with either kind may be readily understood.

The drum of the roller-wheel *D* is divided into ten numbered parts, and each number represents one square inch; the spaces between the numbers are divided into ten graduations, each one of which represents one-tenth of a square inch. The vernier *E* has ten graduations, one-tenth less than those of the roller-wheel and if one of them exactly coincides with a graduation on the roller-wheel, it represents — counted from zero — so many hundredths of a square inch.

The counting disc *G* is geared to the wheel in such a manner as to rotate once for ten rotations of the roller-wheel; it is divided into ten numbered spaces, each one of which represents ten square inches; its office is to count the revolutions of the roller-wheel. The counting disc is wanting in the No. 1 planimeter.

Referring now to Fig. 1, and supposing that a certain area has been measured, from zero, we may read the result as follows: We find the figure on the counting disc which has passed the line on the post *J* to be 1, representing tens, and the figure on the roller-wheel which has passed zero on the vernier to be 4, representing units; and the number of intermediate graduations on the roller-wheel that have also passed zero on the vernier to be 7 (shown by the dotted line *a*), representing tenths; and the graduation on the vernier which exactly coincides with a graduation an the roller-wheel to be the third one from zero, which we call 3 and represents hundredths; then we have 14.73 square inches as the area of the figure measured.

If the movement of the roller-wheel had been three one-hundredths less, its seventh graduation would have coincided with zero of the vernier and there would have been no hundredths to read. The reading would then have been 14.7 instead of 14.73.

By this it will be seen that with the No. 2 and No. 3 instruments we read from the counting disc *tens*, and that with *all* the instruments we read from the figures on the roller-wheel *units*, from the graduations on roller-wheel *tenths*, and from the vernier *hundredths*. If the same area had been measured with a No. 1 Planimeter, *having no counting disc*, the reading would have been 4.73, because the roller-wheel would have made one complete revolution without being recorded, for which we must add 10 to make the result the same as in the first instance; thus $4.73 + 10 = 14.73$. One's knowledge of areas should enable him to judge whether the area being measured is more or less than ten square inches, so that no mistake need happen when using a No. 1 Planimeter.

When one has become familiar with the use of the Planimeter, it will not be necessary to set the wheels at zero for each measurement, but their reading as they stand just before beginning to trace a figure or a diagram may be noted down, and this quantity subtracted from the reading when the tracing is completed. The *difference* between the two readings is the result sought. For instance: If we take the reading of the wheels as they stand in the cut (Fig. 1) for our *old* reading and measure another figure or diagram which gives us a *new* reading of 17.21, then $17.21 - 14.73 = 2.48$ square inches, the area of the figure last measured.

If, with a No. 2 or No. 3 Planimeter a new reading is found to be *smaller* than an old one, it is because the *zero* of the *counting disc* has passed the index line or point, which makes it necessary to add 10 tens (which is 100) to the new reading before subtracting the old. For instance: If our old reading was 98.76, and after again tracing the outline of the last diagram we find the reading to be 01.24, then, adding 100 (which is the same as prefixing one digit to the left) we have $101.24 - 98.76 = 2.48$ square inches, the same as before.

If with a No. 1 Planimeter, a new reading is found to be smaller than the old one, it is because the *zero* of the *roller-wheel* has passed the zero of the vernier, which makes it necessary to add one ten (which is 10) to the new reading before subtracting the old. For instance: If our old reading was 8.76, and after tracing the same diagram as in the last instance we find the reading to be 1.24, then, adding 10 (which is the same as prefixing one digit to the left) we have $11.24 - 8.76 = 2.48$ square inches, the same as with the other instruments.

# Directions for Using Amsler's Planimeter.

The Planimeter is a precise and delicate instrument, and should be handled and kept with great care, in order that it may be depended upon to give accurate results.

After using wipe it clean with a piece of soft chamois skin.

Have a *flat, even, unglazed surface for the roller-wheel to travel upon*. A piece of dull finished cardboard serves the purpose very well.

To find the area of a figure with the Planimeter, place the instrument on the drawing (whether a plan or indicator diagram), in about the position shown in Fig. 2, so as to allow perfect freedom of motion in every direction in which it is necessary to move; place the weight in the position shown at *P* and press the needle-point down gently so that it will hold its place.

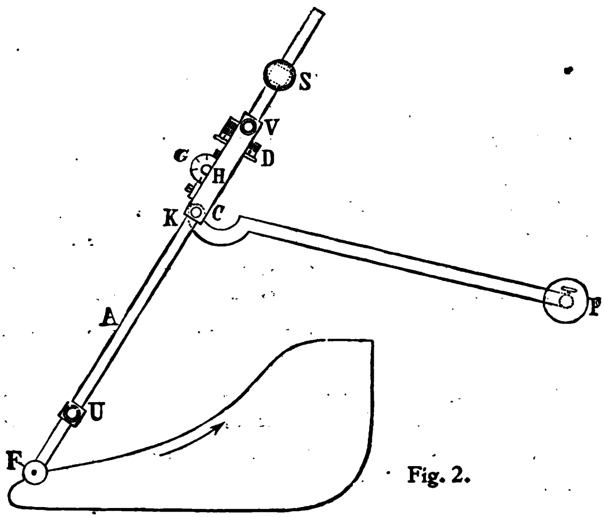



Fig. 2.

Put the point of the tracer *F* upon any given point in the outline of the figure to be measured, and either adjust the wheels to their respective zeros or take a first reading where they happen to stand. Follow the outline of the figure carefully with the tracer-point, moving it in the direction indicated by the arrow, or that of the hands of a watch, until it returns to the starting point; then the index must be read as directed in the description of the recording mechanism under Fig. 1.

Great care should be taken to have the instrument *in position* to trace an outline before setting the wheels at zero or taking an old reading, and also to take a new reading as soon as the tracing is completed, as the least movement of the tracer-point will change the result.

If it is an *indicator diagram*, and we have found the area as above directed to be 2.48 divide this by the length of the diagram, which we will assume to be 3 inches, and we have .8266 + inches as the average height; multiply this by the scale of the spring used in taking the diagram, which in this instance we will call 40, and we have 33.07 pounds as the average pressure per square inch on the piston, or the mean effective pressure M. E. P.

Suppose with the wheels at zero we measure another indicator diagram of the same length, and we read from the figures on the roller-wheel 3 (units), from the graduations 0 (tenths), and from the vernier 8 (hundredths), it should be written down 3.08 square inches; then, $3.08 \times 40 \div 3 = 41.07$ M. E. P. It is better to multiply first and divide last, to avoid troublesome fractions.

If the figure is drawn to a scale, multiply the result by the square of the scale, for the actual contents of the surface which the drawing represents. For instance: If the figure is drawn to the scale of one inch to ten feet, and the result of our measurement is the same as before, viz., 2.48, then we have 2.48 $\times$ by the square of 10 which is 100=248 square feet, as the *actual area* of the surface of which our figure is a *plan*.

When measuring a small area, like an indicator diagram, the reading of the counting disc may be disregarded.

When a figure or diagram is too large to be measured in the ordinary way with the needle-point of the Planimeter outside the limits as in Fig. 2, it may be measured by setting the needle-point *inside* near the middle. We should then proceed as follows:

Circumscribe the diagram with the pointer as usual, watching at the same time the counting disc to see whether the total rotation of the roller is a forward or a backward motion. This question being determined, proceed now to measure the figure *carefully*, following the curve accurately with the pointer. If the total rotation of the roller has been a *forward* motion, subtract the first reading from the second and add the difference to the figure engraved on the top of the weight used for keeping the needle-point in its place. (This figure, which is the constant of the Planimeter, varies slightly on different instruments.)

| | |
|---|---|
| Example: Second reading, | 45.37 |
| First reading, | 34.38 |
| | 10.99 |
| Figure on weight, | 271.32 |
| | 282.31 square inches. |

If the total rotation of the roller is a *backward* motion, subtract the second reading from the first reading, and *subtract* the difference from the figure on the weight.

Example: Complete first reading, 127.32
Second reading, . . 82.35
44.97

Figure on weight, . 271.32
44.97
226.35

## SPECIAL USES FOR THE No. 3 PLANIMETER.

The No. 3 Planimeter is somewhat differently manipulated, although the same general principle pertains.

The sliding bar *A* is marked with several vertical lines, beside which are engraved the value and denomination which the instrument will measure, when set to that particular mark, by one complete revolution of the roller-wheel; it may be square decimetres, tenths of square feet, or square inches. The sliding bar may be fixed or released by means of the set screw *S*. To set the bar for measuring square inches, move it so that the vertical line of the 10□ inch mark shall coincide with a similar line on the sleeve, through which the bar slides at *K*, see Fig. 1, and read the results of measurements as directed thereunder.

When measuring areas with the bars set at the 1□ decimetre mark,

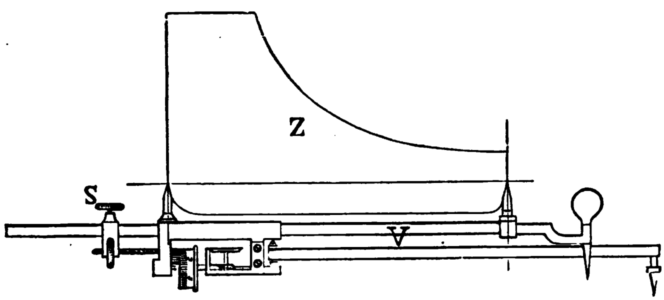



Fig. 3.

read as above directed and multiply the result by 0.1. Example: If the reading is 12.46, then 12.46 × 0.1 = 1.246 square decimetres.

When measuring areas with the bar set at the 0.1□ ft. mark, read as above directed and multiply the result by 0.01. Example: If the reading is 13.75, then 13.75 × 0.1 = .1375 of a square foot.

To find the average height of an indicator diagram at one measurement, measure the length of the diagram on a line parallel with its

atmospheric line, accurately between the steel points on the bar, as shown in the cut. (Fig. 3.)

*With this adjustment* the figures on the counting disc represent hundreds, those on the roller-wheel tens, the intermediate graduations units, and the vernier gives the decimal.

Place the instrument in position with the wheels at zero, and trace the outline of the diagram as before directed. The result of the reading will be its *average height* in fortieths of an inch.

After measuring the diagram suppose we read (disregarding the counting disc) from the figures on the roller-wheel 3 (tens), from the graduations 5 (units), and from the vernier 2 (tenths); then we have 35.2 *fortieths* of an inch, which, divided by 40, gives .88 of an inch as the average height. This, multiplied by the scale of the spring used, which in this case is 60 lbs., and we have 52.8 lbs. M. E. P.

A simple process is to multiply the reading by the *factor* corresponding with the scale of the spring, which for a 60 lb. spring is 1.5, then we have $35.2 \times 1.5 = 52.8$ lbs., the same as by the other process.

Following is a list of the indicator springs which are commonly made with their corresponding *factors* immediately below:

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Springs, | 8 | 12 | 16 | 20 | 24 | 30 | 40 | 50 | 60 | 80 | 100 | 120 | 150 | 180 |
| Factors, | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.75 | 1.0 | 1.25 | 1.5 | 2.0 | 2.5 | 3.0 | 3.75 | 4.5 |

When two diagrams are taken on the same card, they may be measured conjointly and the average height divided by 2 to get the average height of both. We, however, recommend that each diagram be measured separately, especially if there is a difference in their areas, which is generally the case.

The use of Amsler's Planimeter in the measurement of indicator diagrams, enables one to measure ten cards with it in the time which would be required to measure one card without it, and insures the utmost accuracy in the work.

Respectfully submitted,

G. W. Wildin,
C. B. Conger,
W. G. Wallace,
W. P. Steele,
A. S. Erskine,
Committee.

The President: Gentlemen, you have heard the reading of Committee's Report. It is now open for discussion.

The President: Ladies and gentlemen, I have the pleasure of introducing Mr. P. M. Arthur, Grand Chief of the Brotherhood of Locomotive Engineers, who will address a few remarks to us.

## ADDRESS OF GRAND CHIEF P. M. ARTHUR

..... of the .....

### BROTHERHOOD OF LOCOMOTIVE ENGINEERS.

Mr. President, Ladies and Gentlemen. I will take the privilege of addressing you as brothers and sisters, any objections to that? Cries of "No!"

We are of the same family, so far as I understand the aims and purposes of your association; most of you at least are locomotive engineers, if you were not and had not been, you would not be members of the Traveling Engineers' Association. I am pleased to meet with you and as I look into your faces my thoughts revert back to the days when there were no associations whatever of railroad men. I have been very much interested in reading the reports of your Committees appointed at your last convention; the questions and answers are something new to me.

When I commenced railroading, some forty-eight years ago, the locomotives of that day were not what they are at the present; we knew nothing of the modern improvements and attachments of the locomotive of to-day; we knew nothing of the steam gauges, water glasses, and I might say, what is known as feed-cocks were unknown in those days.

The first locomotive that I fired was a little single driving wheel engine called the Ben Marshall, running between Schenectady and Troy, better known to-day as the New York Central & Hudson River Ry. System. We had at that time five or six distinct and separate organizations, first the old Albany and Schenectady, known before that as the Mohawk and Schenectady, then the Schenectady and Troy; Schenectady and Utica and the Rochester and Buffalo; all separate and distinct corporations.

In 1853, I speak of this my brothers for the information of the younger men, it may be well known to the older men, but the engineers of the present day are young men and know but little of the time I speak of unless they have read the history of railroading during the past fifty years, of the many improvements that have been made in railroading and railroad equipment. In 1853 the Legislature of the State of New York passed what was

known as an Act of Consolidation, permitting these separate organizations to organize under one head; a charter was issued, a name given, it was known as the New York Central Road extending from Albany to Buffalo; later on after old Commodore Vanderbilt got control of the New York Central, being at the head of the Hudson River, known before as the Hudson River R. R., they consolidated with the New York Central, hence the present title, New York Central & Hudson River R. R.

Well do I remember, brothers, after the Legislature of that State passed that Act, they were given an excursion over the road to Niagara Falls; every switch on that road from Albany to Buffalo was spiked; the best of hard wood was selected for the engines and two firemen placed upon the engine; the aim was to give the Legislature of the State of New York a fast ride to Suspension Bridge, and when I think of the time that was made upon that occasion, of the rivalry existing among the men on the different divisions, each one striving to do his best; when I think of the time made and compare it with the time that is being made all over this country to-day, especially on our trunk lines, it is not to be considered for one moment as fast running. The best time that was made was thirty-nine miles an hour, but taking into consideration the track and everything else, it was fast time on that occasion.

I remember well when we returned, as the train pulled into the siding in Schenectady where I was, Chauncy Vivard stepped off the train and handed to the crew of that train a five dollar note. I do not know as it would be hardly proper or appropriate for me at this time and on this occasion to refer to what was done with the five dollars at that time. There is such an improvement made in the moral standing and character of railroad men as compared to that time that I will let the past go and refer to the present. The advantages presented to the young men by and through your Association cannot be estimated in dollars and cents, and it is very necessary if you expect to succeed as locomotive engineers that you avail yourself of the opportunities and advantages presented by this Association to educate yourselves up to a high standard of excellence in your profession. Every young man's future, let it be on the railroad or elsewhere, depends upon his own individual efforts; that is a thing that I wish to impress upon your minds, remember that the stream never rises above its source and a man never rises above the height at which he aims and my advice is, always to aim high; whatever you undertake, do it the best you know how. As I have often told the railroad men on different occasions in meeting with them; if you are a fireman, aim to be the best on the road; if you are an engineer, aim to be running your engine as economically as possible, so that by your daily labor and

conduct you will impress upon the minds of your employers that you have some interest in their welfare outside of the dollars and cents you earn. Just think of it brothers, the advantages afforded you to day compared with that they were when I commenced forty-eight years ago. That is quite a long time when we think of it, yet when we remember what has been accomplished through the various organizations we have reason to feel proud of the record we have made as an organization known all over this country as the Brotherhood of Locomotive Engineers. When you think of the work that is being accomplished by the different organizations it certainly is encouraging, and ought to be to every man identified with the railroad service.

I am free to confess that when your Association, Mr. President, was first established I knew little of it and the question was asked me, "Can I join The Traveling Engineers' Association?" by a member of our Brotherhood. At that time I said "No," because I did not know what your aims and purposes were. The fact that you were called "The Traveling Engineers' Association" conveyed to me that you were an organization representing a particular branch of labor and under the laws of our Brotherhood I knew that you could not join any other organization, hence my reply to the young man was "No," but when your President of that day, Brother Conger, explained to me your object, I immediately wrote "Yes, you may join."

So my brothers when we come to understand the aims and purposes of another Association then we can unhesitatingly recommend and advise, but until we do, it is all wrong to advise any person without you first understand the advantage to be attained.

I can only say, Mr. President, that I appreciate very highly the good work your Association is doing, and if there is anything in my official or individual capacity that I can do to encourage you in your good work, you need not hesitate to call upon me and I shall never allow an opportunity to pass, let it be public or private, to speak of the grand work that has been accomplished by the different organizations composed of railroad men, and while the Brotherhood of Locomotive Engineers are the pioneers in this grand work, we have never been foolish enough to believe that we were the only one. I know there have been a great many insults and slurs cast at the Brotherhood Chief, we have been charged many times with striving to establish an aristocracy of labor; I have said in reply, if this means to be economical, frugal, industrious, saving their money, and abstinence from drinking saloons and gambling places, if such as this is what is termed aristocracy of labor, I am proud of the title.

No organization can exist unless you give it tone and character, both individual members and the organized character; without

it no great good has ever been accomplished; we all have our own ideas and notions, I have mine, but I have always been liberal enough to say to our brothers, "I concede to every living man the same rights and privileges I ask for myself, nothing more or less." We have been charged very frequently with dividing men, keeping them apart; it is false. I have always been a warm friend and advocate of organized labor, honest labor; I have differed with many men who are the supposed leaders of labor organizations; I have differed with them as to the best methods to be employed to obtain certain results, but because I differed with them is it any reason why you should charge me with wrong motives or curse me? Besides there is no argument in anything of that kind. We all are liable to make mistakes; I do not know whether you ladies have ever lived in a neighborhood where it was necessary to build high fences to keep from quarreling; let it be strictly understood the policy of our brotherhood is one of non-interference. We have, and believe that every organization founded on good business principles will succeed; as the tree is known by the fruit it bears, men are best known by their works and that rule and principle can be applied to labor organizations as well as every other association.

It is not necessary for me to go upon the house tops and proclaim your good works, your neighbors know; those who live in the neighborhood best know whether you are honest or not, whether you are industrious or not.

Now my friends I can only say in conclusion, that I take pleasure in meeting with you this morning and giving you this little informal talk. When invited to address you by your President some time ago I said to him, if in the city I would gladly come and give you a talk, not an address, but a plain ordinary talk, and if I have said anything this morning that will convey to you a thought that you can take home, think it over carefully and see whether or not what I have said is detrimental or beneficial to the best interest of the railroad men and their families. As I have said, I have been a railroad man for forty-eight years; perhaps some one may say, you're a pretty old man, and so I am. I commenced railroading in 1852, now you can guess pretty nearly how old I am. Some of our brothers call me "the old man," that is a common expression of railroad men and often applied to the Master Mechanic; if you are loafing, look out for him; you may be in the fire box smoking or in the shop and some one will say, "There comes the 'old man' look out for him," and there will be a skedaddling. My friends, the wheel of time is continually revolving, we cannot stop it. Some times we would like to and perhaps if we could have our own way we would stop it for a while but that is beyond the power of man; all we should aim to do is, while here, to so live that when God calls us hence it can

be said of us, a good man has gone. What is life after all unless it can be said of us that we have so lived that when gone there is a vacancy that is hard to fill. Let each one of us strive to do our part, as we understand it, let us extend to every other man the same privileges we ask for ourselves, let us endeavor to so live that when the end comes and we receive the call, it may be truthfully said of you that you have been faithful. May God bless your organization. (Great applause.)

President Stack: Mr. Arthur, on behalf of the Association, I wish to thank you for your very kind talk to us. I would like to have some of our old members make a reply, and will call on Mr. Currie.

J. C. Currie (Nathan Mfg. Co.): Mr. President, ladies and gentlemen; it affords me great pleasure to be here this morning and listen, as I have done many, many times, to the words of counsel and advise from our Grand Chief, P. M. Arthur. If we would only endeavor to profit by such advice, by the sentiment expressed, how much better we would all be as men and women. I am not prepared to make any lengthy remarks, it would be needless at this time, I am sure you want, and I want, to keep fresh in our minds what has been said to us by the Grand Chief. Anything from me at this time would be out of place and I believe I voice the expression of all when I say I am very glad to have been here this morning.

C. B. Conger (Locomotive Engineering): Mr. President, I move a rising vote of thanks be given to Grand Chief Arthur by the Association.

Seconded and Carried.

P. M. Arthur: Mr. President, ladies and gentlemen; I appreciate your kindness, it is very gratifying to know when you have made a good impression—I think you all feel that way; you would like to know if you have made a good run, to have someone tell you of it; if you have been economical during the month and have saved fuel and oil, you like to know that it is appreciated, and I am very much gratified at this expression of yours this morning. As a word of caution to the young men I want to relate a little story; you will pardon the relation I make to myself, no man need be ashamed to stand up and tell of his past, provided he has striven to make the best use of the time God has given him.

You will remember in 1894, brothers, I do not know whether any of you were implicated in that trouble or not, but it was known as a "sympathetic strike." The ladies do not like to hear about strikes because they are the ones to suffer, but there is a moral in this little story for the benefit of our brothers whose sympathies were enlisted for others, without giving the matter due thought of the effects they might produce on the future. When a boy, I hired out to a farmer in the fall of the year; in those days you could hire able bodied men for $13 a month to till the ground, dig potatoes, etc. I hired out to a farmer for two months in the fall; he had a man named Joseph Lasher—I remember it well, the circumstances, I think, I shall always remember; it taught me a lesson. This farmer proved to be one of those kind of men who wanted to get all out of you he could, when you could not work out of doors you could chop wood in the shed; there are such farmers today. When he found that I could cut as mu h corn and dig as many potatoes as Joe could he concluded he would let Joe go and save $6.00 a month; he came to me and told me, Joe heard of it and be said: "Pete, Jim is going to discharge me, I can sue him because I have two more months to work and have a contract with him, but you are doing as much as I and I get thirteen dollars." "Well," I said, "Tell me what to do." "If he discharges me we will go off and get a job together." I said, "I'll do it." Sure enough the man discharged Joe and I quit, the man found himself in a bad fix; he had to have his corn cut and he concluded to take Joe back, and I was left out in the cold. Think it over brothers when you are called upon to sympathize and assist others, think of it. There is a lesson in it. We have a great many good men who mortgaged their homes, their situations and associations of twenty-five and thirty years standing out of sympathy for others who had no claim on them whatever. When you get home just remember the little story I have told you."

Secretary Thompson: I wish to announce that arrangements were made with the Pullman Car Company for half rates for the members and their families and friends attending the convention; the mode of procedure was to pay your fare to the convention, take a receipt for it and present your receipt to the Pullman peo-

ple at Cleveland, when a pass would be issued for the return trip. The Superintendent was up here this morning and if you will go to room 5 at the Union Depot he will issue your return pass at any time between now and the close or any time after that.

The Arrangement Committee wish to announce that there will be a trolley ride this afternon for the members and their ladies and their friends leaving the hotel at two o'clock sharp.

The President: We will now have an intermission of five minutes to allow the ladies to retire.

The President: Gentlemen, we will now come to order.

Secretary Thompson: Mr. President, we have an application for membership for Brother P. M. Arthur, Grand Chief of the Brotherhood of Locomotive Engineers, to be made an honorary member of the Association, which is very satisfactory I am sure to all members concerned and I make a motion, Mr. President, that we make him an honorary member without dues.

Seconded by Mr. Long.

The President: Gentlemen, you have heard the motion made by Mr. Thompson and seconded by Mr. Long, that this Association make Mr. P. M. Arthur, Grand Chief of the Brotherhood of Locomotive Engineers, an honorary member of this Association without dues. All in favor will give the usual sign; contrary.

Carried.

Mr. Arthur: Mr. President, I wish to thank you and through you the brothers for this compliment, and as I have some other business which requires my attention, before I leave you I would like to read, if there are no objections, a little clipping for the benefit of the Master Mechanics who are here; I notice Brother McKenzie and Mr. McKee. In my opinion it was so good as I read it that I thought I would like to read it here; it is from a gentleman who is well known all over the country and he is known as a broad minded man, liberal and nothing narrow about him; it is Mr. J. Kruttschnitt, Fourth Vice-President and General Manager of the Southern Pacific System. In reading over our exchanges I found this and I cut it out. It gives his opinion of the requirements and qualities needed to be a successful Master Mechanic and I think the same must apply to men occupying your position, because you are occupying positions of responsibil-

ity and trust; you are the go-between the engineer and the Master Mechanic and General Manager; you have general supervision of the engines, and to be a success at your business some of the things that Mr. Kruttschnitt said I think would be beneficial to you. I will read it if there are no objections.

SPECIFICATIONS FOR A MASTER MECHANIC.

Mr. J. Kruttschnitt, Fourth Vice-President and General Manager of the Southern Pacific, in a recent communication to the Pacific Coast Railway Club, gives his specifications for a master mechanic: "A successful master mechanic must be two-sided. He must not only keep the machinery under his charge in proper order, but he must discipline, direct and control the animated human machine that operates the inanimate tools or engines. He should, therefore, be a good mechanic as well as a good leader of men. He should be familiar with tools, and should understand theoretically and practically the locomotive and other steam engines, as well as the laws of combustion. He can not ignore gas and petroleum motors. He should cultivate the habit of critically analyzing operating results shown in statements issued from his own and the accounting offices. He should be a student of current technical literature. He should attend the meetings of technical societies, and under no circumstances should he fail to study their proceedings. He should cultivate a spirit of relentless self-criticism; should never be quite satisfied with what he has accomplished, and should determine to excel all others engaged in his particular line of work. To be a good leader of men, he should cultivate perfect patience, forbearance and self-control, remembering that no man ever controlled others who did not start by controlling himself. He should be even-tempered, or, if not born so, should not let any one discover it. He should be strictly just, granting cheerfully everything due his employees while jealously guarding his employer's interest, curbing his generosity in spending funds entrusted to him. A man so qualified should make a successful master mechanic, but would not long remain one in the present day of keen competition in all branches of railroad service."

If a man can control himself he will have no difficulty in controlling others. Brothers, in leaving you just permit me to give you a scriptual quotation; there is no politics in it, no religion, simply a quotation; I know the railroad men well, we all have our faults, we all have our tempers, but I take this position and I present myself as a living witness, there is no man who has posses-

sion of his reasoning power and his will power, that inherent power that God has given him, but who can, if he will, control himself; "He that ruleth his own spirit is greater than he that taketh a city." Now do not understand me as being opposed to animated discussions, your ever-to-be-commended discussions? a man who does not warm up with his subject and become animated is a failure every time in a discussion where there are opponents to be met; that is all right, that has nothing to do with the temper, and when a man learns to control himself he will have no difficulty in controlling others, and the position you gentlemen occupy you are brought directly in contact with the men in the service, and my advice to you is to endeavor to control yourself. If you feel the "old boy" rising up, grapple with him, and remember if you do that you will have less difficulty in controlling others. You would be surprised if I were to tell you about myself—but I will not say anything about that; I will simply leave you after saying that you have my best wishes for your success, and if there ever comes a time when you and the Locomotive Engineers employed upon the road have any friction, remember that after hearing both statements, those in authority will be in position to judge them impartially, and so I bid you good day.

The President: We will now proceed to the discussion of the indicator subject.

D. Meadows (M. C. R. R.): I have a question I would like a little information on. We will suppose we have an engine with valves that have been set square with the tram, but in this engine the piston clearance is a little off, due to the fact that the main rod is either too long or too short. We will say the piston clearance is $\frac{1}{8}$ of an inch at one end of the cylinder and $\frac{3}{8}$ at the other, will the indicator show this? We know that if an engine is running at short cut-off the exhaust will not sound square, if the clearance is not divided equally.

G. W. Wildin (Plant System of Rys.): If the engine's valves have been adjusted as stated by Mr. Meadows and the engine is working at moderate or short cut-off, the indicator will reveal the fact that the clearance is unequal at the two ends of the cylinder, and we can readily recognize the fact by comparing the compression lines of the cards from the front and back ends of the cylinder.

C. B. Conger (Locomotive Engineering): In this case you have to take the two cards in order to show where compression begins at each end of the cylinder; if it begins at the same point in the stroke of the piston at each end and the compression line is higher on one end than on the other, we would conclude that the compression line running the highest had the least clearance. The indicator shows the exact point where compression begins and you can figure that the valve is just so long from the steam edge to exhaust cavity, from this you can figure where compression should begin; then if it shows a great deal higher on one end than the other I would figure that there was less clearance space at that end because the rise in pressure was so much higher.

G. W. Wildin (Plant System of Rys.): I might state that with all valves which are line and line inside, compression begins at exactly the same distance from one end of the card as the release does from the other.

J. F. Walsh (Galena Oil Co.): It is a number of years since I have paid much attention to the indicator question, but I must say that some of the most interesting experiments which I have seen in recent years were conducted some six or eight months ago by the Norfolk & Western people relative to the compression caused by men failing to operate or handle their engine properly after steam had been shut off. Now I am free to confess that I do not know whether the committee who so splendidly handled this question went into this feature or not, but I will take a moment to go over the matter. It was suggested that the practice commonly found, and followed, on railroads by many engineers, of shutting their engine off and allowing it to run down a long grade without dropping the reverse lever down, was a most reprehensible one. In order to determine to what extent it was bad practice they took up this matter with the indicator. Now, if you will give me a sheet of paper I can illustrate better, (illustrates). Now suppose we were running an engine with 18-inch by 24-inch cylinders and we allow her to run down hill at the rate of 30 to 35 miles an hour with the reverse lever cut back to 18-inch valve cut-off, this would be about the kind of a diagram you would get from this engine. (Illustrates). Now to let this same engine roll down hill, shut off with the reverse lever dropped down full

stroke, this would be about the kind of a diagram the indicator would show. (Illustrates). Now I recommended and do still recommend, that where you have a great amount of running down hill with your engine shut off that it is an excellent idea after you have shut the engine off to drop the reverse lever down to nearly full stroke, and crack the joint of the throttle valve. I will illustrate this with cards from this same engine. I wish I had brought blue prints with me, I have them. (Illustrates). That would be about the kind of a diagram we might expect under the same conditions. This illustrates to you what good effects are produced by following that practice, and I think it will bear out the fact that a great deal can be learned by the use of the indicator. That is about as far as I can go from recent experience with the indicator, but this is one of the valuable things, in my opinion, brought out by the indicator.

G. W. Wildin: At any time did the lower line of the card drop below the atmospheric line?

J. F. Walsh: Yes; and another point, was the discontinuance of the use of the by-pass valve; the Norfolk & Western people after experimenting with the indicator found that the by-pass valve did not give them very great results in a simple engine.

D. Meadows: I would like to ask in connection with the question I asked before, if the compression line would not be somewhat similar in this case, to what it would be if the valve were not square.

G. W. Wildin: It might so happen that the compression lines in the two cases cited would be similar, but in case the valves were out of square other lines of the card would be affected as well as the compression line, and this fact would show very readily.

C. B. Conger: If the valves are out, cards taken from the two ends of the cylinder would not show the same results for compression, but at the same time the indicator would show somewhere on the card the fact that the valves were out. Let your compression line alone till you get your valves square, then if the cards show that compression is greater at one end of the cylinder than at the other we would conclude that the clearance space is larger at one end than the other—this could be caused by the main rod being either too long or short. You will have to examine the

other points on the card to determine whether or not the valves were aiding compression by closing too early on the stroke.

G. W. Wildin: The first thing to know is that your valves are square, you cannot rectify anything unless you know wherein it is wrong; the fact that the valves are out is not hard to determine, you can tell that by simply looking at the card.

L. D. Gillett (N. & W. R. R.): We have, as Mr. Wildin told us, passed over the various stages of this indicator question on the Norfolk and Western R. R., and I believe, Mr. Secretary, I sent you an extract from Mr. Seley, our Mechanical Engineer, which I presume Mr. Wildin got, that pretty nearly covered the points. As far as the question of the indicator is concerned I may say, it is an absolute feature, it is the feature to give you economy, it is the feature to expose the deficiencies in every particular in regard to valves or pistons. But you will have to excuse me this morning—I will call upon Mr. Collins to give you the measures that were taken of the coal, etc., that was consumed on the different tests we made; we made a number of them all with simple engines, so if Mr. Collins will kindly give you what points he can from memory it would be a benefit to all, I am satisfied.

Mr. Collins (N. & W. R. R.): I regret that I did not bring this data with me. The reason we first determined to make these tests was this, the engineer would close his throttle with the valves cutting off at about 8-inch stroke, and would not drop the reverse lever forward on account of laziness. It was found that this practice when followed, would create a knock or pound in the engine. We took the cards to the men and explained to them that if they did not drop the reverse lever, the next best thing to do was to overcome this compression difficulty by cracking the throttle slightly.

F. M. Nellis (Locomotive Engineering): I do not know as I can add anything to this valuable and able paper, I may say, however, that I think it is one of the best papers ever presented to the Association. In this part, page 109, referring to the good distribution of steam, we all believed that when an engine sounded square it was in good condition, but when we get the report the Committee shows here that we do not get the very best results from an absolutely square engine; of course it does not follow

that an engine that is "out" is better than an engine that is square. If an engine is out a little after the indicator has been applied to her it shows, that while she is out, still we are getting the best distribution of steam; I think the paper is right in saying that the proper way to set valves is by the indicator and not by the tram; of course we can get valves pretty close with the tram in the shop, but I think the proper way to get the engine down to the finest point is to use the indicator, and I think too, that the practical engineer can do a great deal toward making a better engine by using the indicator. Here on pages 108 and 109 reference is made to the letters "A" and "B" on the expansion and compression curves on the card figure 19, the "Allen Port Open;" now on the card that "A" and "B" is not given and I know it caused me a little worry before I found out what it meant, and I would suggest that the Committee supply that "A" and "B."

G. W. Wildin: That "A" and "B" appears on the drawing sent the printer and we will have to look to Mr. Thompson for that correction.

F. M. Nellis: The paper is so complete that I cannot add anything to it. I have learned considerable of the indicator from this paper and I think it is the best paper of its kind I have ever seen; so many papers given are so full of technical terms and mathmetical expressions that it is very hard to get to the bottom of the indicator subject, but here it is given in such a way that anybody ought to be able to understand it. The data it gives in parts three and four is splendid, I know I shall prize the proceedings when they come out for the special value of this paper.

G. W. Wildin: If the members will turn to page 115 they will notice a very interesting example of an engine being "out" and yet sounding all right, you cannot tell what your engine is doing by the sound. Cards 4 and 5 were taken from an engine on The Plant System. I had occasion to ride with the engineer on my way over to apply the indicator and she certainly sounded to me as nice as any engine could. The engineer said, "Well, I don't think you will find anything wrong with this engine." Card 4 is what I found. I noticed while riding this engine when we stopped at stations, the engineer would necessarily have to take the slack on a passenger train of 5 cars in order to start, this led

me to believe that something was wrong and when I put the indicator on I got card 4 and after adjustment I got card 5, you will notice card 4 has excessive back pressure from 22 to 27 pounds. I would like to ask Mr. Gillette a question since he referred to Mr. Seley's letter. Mr. Seley in his letter made a statement that he had been convinced that to apply the indicator to all engines turned out of the shop for the purpose of valve setting was the proper thing, and did so, on a road with which he was formerly connected, but on that road the work was carried on in the yard with three or four box cars attached to the engine. Runs were made up and down the yard and the valves adjusted for different cut-off; he concluded with the statement that after an engine was found to be square and the distribution of steam proper after this test there would be no difficulty experienced at high speed, which statement I question very much. I would like to know if he still follows this practice?

D. Meadows: How did this engine sound after the change was made after taking card 4?

G. W. Wildin: It did not sound as well as before, but I only indicated one side. If the other side had been gone over the same as this, there would have been no question at all about the sound.

C. B. Conger: It is a fact that the valves can be set by the tram so they are square, they can have 3-16 inch lead, or be ½ inch blind and she would still exhaust square; the indicator finds this out. I think the reason the traveling engineer and engine men have such a prejudice against the indicator is because when it is applied to an engine by the principal of some college or by the mechanical engineer of a road the result comes out in algebraic formula, p-d-q equals x-y-z and they look it over and say "that is all right for the expert, but I do not know anything about it, and I do know I have lost a couple of trips while they were monkeying with my engine." I am for practice first and theory afterward; but if we can get the practical men, both the traveling engineer and the locomotive engineer, to absorb a little of the theory we can enjoy both the theory and practice. If on the whole we improve the condition of our power I think we shall have won a great victory. The object of this part number three is to explain

these algebraic terms. There is a glossary of terms used and as we might say, the technical part is put there in proper shape without mixing it with the practical part.

One thing that is complained of by the locomotive engineer is on page 151 in which it says the indicating is done on good engines; the mechanical engineer has some fantastic idea about the distribution of the steam, he says the cards show one way or another with tendencies one way or the other. Now I think after the method of using the indicator and the results that are obtained are brought to the knowledge of the engineer he will advocate its use as a valve-setting device and the tram will be done away with, for the trams do not show where the valves open and close when the engine is working hard; they do not show where the compression begins, in fact they do not show anything at all.

W. G. Wallace (C. & N-W. R. R.): The report of this Committee is on "The use of the steam engine indicator as an aid to the traveling engineer to determine the efficiency of the locomotive in service and the benefits derived therefrom." Now we are just getting some information on this question; a great many of us do not know how to apply an indicator. The traveling engineer, as a rule, has his own troubles; he goes out to a man in road service and says, your coal record does not show up very well. Well, what am I to do with her, I have been running her according to the rules in practice; the engine simply does not do her work. He tells his troubles to the traveling engineer, who will come in the shop and make a report to the Master Mechanic or Shop Foreman, that the engine is not doing what she should, the Master Mechanic will turn the matter over to his next superior and of course he stands on his dignity and says to the traveling engineer that the valves on that engine are set according to our standard method and she is all right; if that engineer cannot run her and make the time pull him off and put a man on who can. The traveling engineer is satisfied that the engine is not what she should be, he applies the indicator to that locomotive, takes the cards and presents them in the office; there is the evidence of the work of that locomotive, beyond dispute. Now if we will make the engine right, we will most likely find the man to be all right; when the engineers understand how to make these changes,

there are many who will go under their engine and lengthen or shorten the blade to get her square, I have found them and assisted them in doing so. The traveling engineer can go right after such men and interest them, show them the card before a change is made and after you will find you will save coal and that is what the railroad companies are figuring on today; that is the way I think this organization should work, on these lines. We are just getting started in this matter; there are a great many of us who have never taken any great interest in it; there are some of us anxious and willing to learn and we should avail ourselves of every opportunity to increase our knowledge. I can say nothing more about the indicator outside of what I have said about the benefits we will get by using it. Of course if we do not use it we will be just as bad off as we were before.

C. B. Conger: Some say the railroad companies are after coal saving. I would just like to say it is "get there" that they are after, "get there with your train," and the indicator will show quicker than anything else, whether the engine has excessive back pressure so it cannot make the time, whether it exhausts at the right time, and it will show a good many other things. It will show if that particular engine is getting there better and cheaper than others of the same build.

W. A. Pitcher (Standard Oil Co.): My experience with the indicator has been very limited, only once in my railroad experience have I ever seen a locomotive indicated, and that was a compound engine that was bought of the Brooks Locomotive Works. Their crew came with the engine and indicated her while she was running on my division. At that time, of course, I gave it very little attention but my experience in the last eight years has convinced me that the indicator is the proper thing. We do not think that an engine room is complete unless we have an indicator to show what the stationary engine is doing. I think that the indicator from a mechanical point is just as essential in locomotive work, in fact more so, than it is in stationary engines, the conditions are different but there is no reason why we should not know how our engine is acting. It is a good deal as others have said, and I will admit, that my experience has been limited; we are all young in that direction and we cannot get too much

valuable information. We expect in time better results will come from those engines, and the indicator will determine just what they are doing. We will have something to bear us out in our statements to our superior officers. So far as this report is concerned, it is the best I have ever seen and I think the committee should be congratulated and thanked by the whole of the Association for the splendid work they have done in this matter.

T. J. Hatswell (F. & P. M.): I cannot say very much about the indicator. I took some cards about four or five years ago and one end of them very clearly showed that with some of the engines which I thought were doing good work the steam was not admitted equally for the two ends, and I think it also revealed the fact that some of the engines were given too much lead down in the corner. Of course from the card you can follow out closely the different lines of the stroke and can determine the amount of work each engine does.

J. A. Baker (A. T. & S. F. Ry.): I do not know as I can add anything to this report, you can hardly think of anything to say that has not been touched upon. About a year ago some cards were taken from our tandem compound, known as the player tandem, and they did show excellent results, the engines seemed to do good work, judging from the cards. I did not take them but Mr. Huffman did. We experienced considerable trouble with the engines, however, at a moderate rate of speed, and the moment you increased the speed there would a pound develop. When the engines were shut off with the reverse lever in the corner they developed so much compression or vacuum in the low pressure cylinder that the men would pull them back toward the center and crack the throttle; they showed considerable back pressure in working. These trials of which I speak were made when the engines first came out of the shop and for about a month they did good work, they did excellent work and suited the service better than the simple engine, but there seemed to be such a prejudice against the compound that it was hard to get the boys to try to do anything with them. I have scanned all these cards over and they have always bothered me, I could not understand why we could get such excellent cards and still not obtain better results in service. Our high pressure valves have 3-16 inch inside clearance,

that is the piston valve; which seemed to give better results than the slide valves. Our instructions now are to put the reverse lever down in the corner to overcome that compression. We have not made any tests during the last three or four years but I shall endeavor to do my best in the near future to get some cards from this class of engines. I had not received the advance copy of the report when I left home, consequently I am not prepared to furnish any further information; being a new member I did not not feel as though I wanted to say much, I wanted to have some-one else do the talking. I am exceedingly glad, however, that I did come. I think the report of the committee is the best I have ever seen; the ground is covered thoroughly. I do not think there is a book published on indicator practice that covers the ground as well as this report, and I think the committee should be congratulated on the excellent work it has done which has opened up a new field, and I think every member of the Association should put his shoulder to the wheel so at the next convention we may be better posted on this subject. We are all a little backward just now because it is a new subject and has never been taken up. I think if this subject could be continued at our next session we will obtain some very excellent reports.

L. D. Gillett: I misunderstood Mr. Wildin a moment ago, I did not know he asked a question, when he referred to Mr. Seley's letter concerning the setting of the valves on engines newly turned out of the shop while in yard service. Now what Mr. Seley did say in his letter was that that was the practice on the road that he was formerly connected with and prior to his coming to the Norfolk & Western Railroad and I might add that it is not the practice now on the Norfolk & Western Railroad.

Eugene McAuliffe: I cannot add anything to the indicator question. I personally want to extend my thanks to Mr. Wildin for the fact that he not only made such able use of his mechanical knowledge but kept in mind at the same time the practical side of the question. Taken from the practical side as well as from the mechanical standpoint I do not think the indicator is a necessity in the determining of striking points, lead openings or anything of that sort; the use that we should make of the indicator is to determine comparative weaknesses, and I believe these points can

only be determined by the indicator. There seems to be a general feeling of interest among engineers on the indicator question and we possibly can do no better when leaving this convention than to go back and make up our minds to acquire a knowledge of the indicator, keeping in view at the same time, the necessity of urging the higher officials, men who have charge of the department, the necessity of taking up the subject, provide means to purchase the apparatus and instruct the traveling engineer in the use of it. I believe that is a necessary point. A great many of our men who came up from the practical side are of the opinion that no man short of a mechanical engineer or a man of marked capacity in that line can handle an indicator. I will confess that until I heard the report of this committee I was of the same opinion. I expect when I leave here to take up the indicator subject, and I think in view of the fact that the Association has practically and thoroughly convinced the older fellows that this will be the leading subject at the next meeting of the Association, more members will be prepared to take up the discussion in a more able and complete manner.

G. W. Wildin: In reply to Mr. McAuliffe's statement concerning the indicators used in determing weakness in construction; the Traveling Engineer has nothing whatever to do with weakness of construction of engines. The Traveling Engineer is given a machine in a more or less perfect condition, he is supposed to get out of it all there is in it with its present condition, and when it comes to a question of design that is to be referred to the department having that under control. One of the greatest things to be learned by the use of the indicator is the proper amount of compression lead, etc., that an engine should have for the service required of it, and that is one of the paramount objects of this committee in handling this report and the Association in taking up this question is to get at these simple points, that the Traveling Engineer is called upon every day to answer; he is asked why an engine does not perform her duty as she should, they compare that engine with some other, they say this one does so and so and that one should. The two engines may be vastly different in their construction; one may have a short eccentric rod and the other a long one; now if you give this

engine with a long rod, for instance, a certain amount of lead in the corner notch, and give the one with the short rod the same amount, you are not going to have the two engines working alike. These are the points we are to look out for.

F. M. Nellis: I think like Mr. McAuliffe that the indicator will be used more for the older engine than the new, in other words they will use the indicator to find out what the old engine is doing. We have previously supposed that so long as an engine sounded square that she was all right, but we did not know anything of exhaust passages being choked. I think the future of the indicator will be more for the old service than the new. There are a great many differences, as you all know, between engines built after the same drawings, and I have no doubt if the indicator were applied to each one of these engines and are adjusted alike there would be less differences; when there is something that cannot be seen the indicator shows just where it is. Now in marine engines they do not have these differences, that is it is, not so marked, and I think that is due to the fact that the engines of each ship are all indicated and they are indicated regularly to know what the engines are doing.

On page 118, plate IX, are four cards which show very conclusively what the indicator will do for the locomotive; there in number one we have a card which shows unusual distribution of steam, one end is blind. The machine in card two was changed, and he made another adjustment in card 3 and in card 4 he made a little angular advance of the eccentric. How much difference between cards 1 and 4. Of course that would have shown up in tramming an engine but not so much as in the indicator system. There is one thing that personally I rather resent that Mr. Conger has said regarding the formula of the indicator; I think that is too much of a reflection upon the man seeking information to come so far and then stop, for the present it may be that is as far as we can go, but we must remember the indicator is a new thing; we have to push ahead if we go with it and we have to know the mathematical part of it which is simple. There is a lot of mathematical numbers which look formidable, but when you come to look at them and find that your p-x means a sentence and the two put together generally means two sentences. It is nothing more

than the short hand of expression; I do not think we should allow ourselves to be stalled by any of the formula contained in here; there are some of us who would like to slip over the formula, but if we are going to make a success in dealing with the indicator what we have to do is to be able to answer the questions that others may ask; we have to go into this enough so that we will not hesitate and say we do not know what x-y-z means, we have to follow that right through.

J. L. Miller (Eastern Minn.): My experience with the indicator has been limited as far as I am concerned; we have the indicator on our road which shows very good results and the question we should ask ourselves is this: Does our Master Mechanic or Superintendent of Motive Power want the engines indicated? Now I have been trying to recommend the use of the indicator ever since I have been a Traveling Engineer, but have never succeeded in getting it; one of our division men said it was not necessary. Just a short while ago we got five engines from one of the locomotive builders, they are built from the same drawings, the tram shows the same on all of these engines. One of them, to use an engineer's expression, "is like an old ice wagon," the rest did the work nicely. Of course I was called upon to right that engine and find what the trouble was, the first thing we did was to set cars out. I noticed the steam gauge and it showed plenty of steam, the same as the others carried; I made my report accordingly. After that report I was given an indicator which told where the trouble was. I do not think there is a member of this Association here but is of the opinion that the indicator would be a grand thing for us to work for. One of the members said we can tell unerringly how the engine works, we want to tell the Master Mechanic how the engine works. An engineer wants a nice square engine to take over the road. There is a body of men in this country whom I think is as well posted as any Association, the Stationary Engineers; with them it is just as the gentleman said, the engine room is not complete without an indicator; now I think the proper thing for this Association to do is to prove to our Master Mechanic, Superintendent of Motive Power, Vice President or Manager, as the case may be, the necessity of using the indicator on all our engines.

C. F. Schragg (M. K. & T.): I consider this one of the best reports I have ever seen. The first time we found an occasion for using an indicator on our road was after we had purchased some compound passenger engines; for high speed, these engines could scarcely make the time; we put the indicator on and found they did not have compression enough, 35 pounds compression; of course that was changed. Afterward we bought a lot of other engines and after they had been in service a number of years they began to fail in doing their work. They would do what the engineers call "go backward" and then start ahead; the indicators were used on these engines and we found that there had been some change made in setting the valves, the low pressure cylinder had such an excessive amount of lead, instead of lapping it would push the piston back as she approached the center. We made the necessary changes, changed the lead and valve gear and the engines pulled better than they ever did before. Since then we have also discovered there was a difference in giving lead in plain and Allen Ported Valves, at least we found it so. All engines that use the Plain Valve we gave a certain amount of lead but had to reduce the lead when the Allen Ported Valves were used as they were likely to make the engine ride hard, and were making themselves very undesirable in other ways. The use of the indicator will be profitable; you ride on an engine and you find she is not running as she should, you go to the Master Mechanic or Foreman and they will tell you that the engine is exactly like the balance and that is all the satisfaction you get; if you go by an indicator all that would be necessary is to show the card and that will show whether the engine is doing the work right or not; if the engineer is wrong it will be shown on the card and for that reason I am very much in favor of trying to get the use of the indicator uniformily adopted if possible.

J. A. Baker: I would like to ask Mr. Wildin if in taking those cards, did you have the piping of your indicator enter the cylinder heads or on the side of the cylinder?

G. W. Wildin: I always have them enter the side of the cylinder, being very careful to get them drilled far enough ahead so there will be a full pipe opening.

C. H. Hogan: I do not know as I can add anything to this

discussion. I must say the committee have made a very able and instructive report; one that will result in a great deal of good. I know that the traveling engineers throughout the country, like myself, will interest themselves more in the indicator and the taking of cards than they have, for the simple reason that it has been so well and simply explained, whereas heretofore we have been in the dark and we have never been given an opportunity by the Superintendent of Motive Power to practice on it, and I must say that I, as well as every man that I have heard speak on the matter, are deeply interested in it, and, as I said before, a great deal of good will come from this report, and what we want today and what we must have to get good results from the locomotive is a uniform distribution of steam and I do not know of any way, in fact there is no way, we can get at the best work of the engine, get at the points that will give us the best results, and most economy, than by the indicator, and as there has been so much said upon it I think every important point has been brought out, and as we have considerable business to do between now and to-morrow night, if it is agreeable to all, I think it would be well to close the discussion. I make this motion.

The President: Does this convention wish to carry this subject over until another year?

Mr. Taylor: There is a question which does not apply to the indicating of an engine and yet it has been touched upon by Mr. Wallace. I should not like to go away from here without speaking of it, and that is the point of shutting an engine off, and dropping the reverse lever in the corner or near approach to it; now that is directly contrary to the instructions that our Superintendent of Motive Power has given the Traveling Engineers and men on our road. We are now instructed to leave the lever in the running position if it happens to be at 6 inches, leave it there except when running at a very high rate of speed, then drop the lever to $\frac{1}{2}$ stroke but never to the corner; that decision has been reached as a result of an inquiry into the cause of broken eccentric straps. It was noticed that the eccentric straps broke almost invariable directly after shutting off at high speed and the question was raised, why at that time, and invariably, as stated, the cause of breaking of eccentric straps was the dropping of the

lever in the corner. From some two years' experience on the B. & M. system we find that keeping the lever hooked up while drifting, decreases the breakage more than 50 per cent. The reason that I bring this matter up is that I should dislike to have my people read this report and have them see that I remained silent.

W. G. Wallace: Some of our men running out of Chicago on passenger trains were instructed not to put the reverse levers in the corner after they shut an engine off not below ½ stroke on account of the size of the valve and short plates.

The President: A motion has been made by Mr. Hogan, seconded by Mr. Meadows that the discussion be closed and this subject together with the committee be carried over to next year; all in favor of this will give the usual sign.

C. B. Conger: Our recommendation on page 153 is that a committee make an investigation for the convention of the facts.

C. H. Hogan: I think the subject is in the hands of a very able committee now, and the manner in which they have handled it is a credit to us all and that they are entitled to a vote of thanks. I move that a vote of thanks be tendered to the committee. Carried.

The President: The original motion made by Mr. Hogan and seconded by Mr. Meadows is before you, that the discussion be closed on this subject and the subject carried over until next year with the same committee that handled it the first year. All those in favor of this motion please give the usual sign. Carried.

The President: We have Mr. McCormick, General Manager of the Street Railway of this city with us today; we would like to hear from him.

Mr. McCormick: I feel very much interested in this discussion. I never was in the motive power department of a railroad in an official capactiy, but I have thought a number of times of the things a traveling engineer has to contend with. I know for a certainty that the Traveling Engineer is often selected by the officials as an indicator on the road, and as the gentleman aptly put it he "got there," and after he was made a Traveling Engineer he had his own troubles, everything was brought to his

notice, good, bad and indifferent. In regard to the taking of cards it strikes me that the indicator is the proper thing; it is not only due to the engineer to know what his engine is doing, but it settles the question of his value; it is due also to the Traveling Engineer to know that his engines are in working order, because his ability is questioned if his freight and passenger trains are not making time. I know on the New York Central road at different times the question discussed by the managers was in regard to the efficiency of the Traveling Engineer. The question which would be brought up time and again was: are that man's passenger trains making time? There is an engineer in the room at present who was on a road where I was employed, and we used to be quite anxious to have a certain train make time on account of competition. We always knew when the engineer I mention was pulling the train it would be brought in on time. I was curious to know what made the difference between engineers, as they had practically the same amount of experience. I want to say, because it may be of interest to you, that the man who made the time, I noticed, was a man who worked a full open throttle and used his reverse lever hooked up; the others would work a half open throttle with the reverse lever three or four notches farther down on the quadrant. I hope you gentlemen will excuse me for bringing up this but I am interested in anything that concerns the engineers and by the use of the indicator it seems to me great improvements could be made, the sentiment of the Association seems to be that managers should have their engines built so that indicator cards can be taken if desired. It is as fair to the engineer as to the company and as far as the master mechanic is concerned, I know he is very largely dependent upon the reports that the traveling engineer makes, so it is a safe guard for both, if such a resolution be passed. I want to ask your pardon again for taking up this question or offering any suggestions, but I would like to have you when you get out to our power station to see our engine there, or anyone here in the city while you are here. I have a trolley car fixed up that I would like to place at the disposal of anyone who would like to take a trip to any part of the city while you are here. Thank you again very much.

C. F. Schragg: My experience with the indicator has been

somewhat limited. While its use is not general on this road it has been used to some extent both on simple and compound engines, and always with advantage. Its general use would be a great help to the traveling engineer. If an engine is not in proper condition to do the work required of her, the indicator card will show it better than the best written report; and if, on the other hand, an engine is reported as failing to handle her tonnage satisfactorily and the indicator shows that there is nothing the matter with her, the Master Mechanic could certainly require no better report. In such cases it would be well, where possible, to use a dynamometer in connection with it. This would show the pull on the drawbar, and if it was the required amount for engines of her class it could readily be seen by anyone that the engine was in good condition whether they knew anything about indicators or not, and might be more satisfactory to the transportation department.

J. V. Murray, (C. B. & Q.) I would like to ask the gentleman if he will have an indicator card taken while we visit the station?

Mr. McCormick. I will see if those indicator cards are here, we have just contracted for a large rotary and we took the cards to send them to the builders; I will try and have cards there when the party reaches the power house this afternoon.

The President. The next paper to be read is "What are the best methods to secure good results in smokeless firing." I will call on Mr. Webb to read the paper as none of the members of this committee are here.

Mr. Webb then read the report as follows:

## What are the Best Methods to Secure Good Results in Smokeless Firing.

*To the Officers and Members of the Traveling Engineers' Association:*

GENTLEMEN: Your committee on the subject, "What are the best methods to secure good results in smokeless firing," takes pleasure in submitting the following: There has been a shortage of replies to the circular letters sent out, your Chairman having received sixteen, and to those who have replied I return thanks for the assistance given your committee.

In order that the exact information may be given as to the answers of those who have replied to the questions in the circular sent out, it will be necessary to give the questions and answers in rotation as per circular.

QUES. 1. Have you experimented in firing locomotives with soft or bituminous coal without emitting black smoke? If so, what has been your success, and how accomplished?

ANSWERS.

"Very little success, only partial."

"Partly successful with light firing."

"We have experimented in firing engines with soft coal with considerable success and realize that smoke can be largely abated by careful firing."

"Have had much experience for the past twenty-five years with all kinds of fuel on locomotives, wood, peet, bituminous coal and liquid fuels. All fuels will throw more or less black smoke, the quantity depending upon the following conditions: The amount of steam you are required to generate within a given length of time, drafts and arrangements of drafts, quality of the coal and the man at the scoop."

"Yes, sir; we have experimented both by patent devices and the education of the fireman, and have found that we get better results by the education of the fireman than in any other way."

"That smokeless firing has been practiced on the Southern Pacific for twenty five years to my personal knowledge, although never adopted as a system under that designation. With certain kinds of coal it is very readily accomplished by means of the brick arch, admitting of air beneath the line of arch in sufficient quantities to furnish the requisite amount of oxygen to unite with the carbon without producing a chilling effect sufficient to prevent such uniting, together with careful firing in order that the volatile matter in the freshly applied coal be not released in greater quantities than can be taken care of by the oxygen admitted over the fire."

"Yes, and with very good success by careful firing and admitting air over fire by tubes inside of fire box."

"By a good fireman, a good engine and engineer."

"There have been no systematic efforts in this direction since my connection with this road, six months. I experimented along these lines when running an engine on the C. R. I. & P. Ry. Excellent results were obtained with the co-operation of an intelligent fireman who fired light, watching the fire closely, regulating the admission of air above the fire as near as possible to obtain good combustion."

"Yes, we have experimented on firing without black smoke and we have accomplished much in this direction, and are well satisfied with the progress made so far. This was accomplished by firing with a thin, bright fire with one or two shovels of coal at a time, firing being done on one side of the fire box, and alternating."

"We have to a considerable extent with very good success, by having the coal broken properly before being delivered to engines. Educating our firemen to fire with a small quantity of coal at a time, i. e., one or two scoops distributed thinly over the fire, and the use of the brick arch and blower."

"We on this road have not made any experiments on the lines indicated in the questions."

"Will say I have experimented for eighteen months past to try and eliminate the black smoke nuisance, and I have succeeded beyond my most sanguine expectations. The only way in my opinion smokeless firing is made possible is by light firing, careful handling of the engine, close boiler feeding and the use of the brick arch."

"By light firing and a good steaming engine."

"I have fired with every coal known to man. I am at present burning oil; have been for the past five years. This of course gives off no smoke unless handled carelessly. I have experimented a great deal through my fireman with bituminous coal."

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QUES. 2. "Have you experimented in firing locomotives without black smoke through efforts and skill of the engineers and firemen only? If so, on what theory did they fire and operate the engine?"

ANSWERS.

"Yes, successful in a great many respects by careful pumping of engine, careful firing, and attention to every detail."

Three of the roads from which we received replies have made no experiments, and two of the roads made no replies to the questions.

"Yes, with but fair success. No matter how light we fire our engines that are not equipped with arches the first two or three exhausts after each charge of coal some black smoke will appear."

Four report partly successful with light firing.

"All the experimenting we have done has been through the skill of the engineer and fireman and the use of the brick arch. The theory they work

on is to have the coal broken up properly. To eliminate smoke in light firing it will be necessary to use the blower a little when the steam is shut off."

"My instructions to engineers are to see that their firemen have their fire in shape before starting. Further I instruct engineers to pull out slowly so as not to spoil his fire, and to hook his engine up as soon as possible thereafter."

"Yes, by the one shovel method, i. e., a small amount of coal at a time and often."

"Careful attention in firing and operating the engine."

"Yes, firing with one shovel, never more than two. The engineer is careful to have boiler full of water starting out, and does not tear fire to pieces by slipping or working his engine too hard."

"It has been found that much depends on the skill used by the engineer in manipulating his engine in doing varied work called for in different kinds of service. More depends on proper application of fuel to the fire than anything else connected with its consumption. We fire with the open-half section fire door improved smoke burning device, firing with one shovel full at a time as required, with excellent results."

"The plan on which the firing was done was to fire light and often."

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QUES. 3. What in your opinion is smokeless firing? Does it admit of any smoke, or is brown or grey smoke tolerated, and dense black smoke only considered poor firing?"

ANSWERS.

Eight replies were that black smoke was considered poor firing, brown or grey smoke tolerated.

Six roads replied that firing with absolutely no smoke is an impossibility, black smoke depending on the quality of coal and the amount of work required to be done.

One replied that smokeless firing permits of no brown or black smoke at all; and one that there is no such thing as absolutely smokeless firing of bituminous coal, that a brown smoke will be emitted when the fire is giving the best results.

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QUES. 4. Do you claim a saving in fuel by smokeless firing? If so, what per cent.?

ANSWERS.

Two roads made no reply.

"Have not noticed any." One reply.

"Yes, about ten per cent." Six replies.

"We do claim smokeless firing is a saving in fuel. Cannot tell what per cent. Have no reliable data." Seven replies.

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QUES. 5. Can smokeless firing be accomplished by any device known to you without skillful firing?

ANSWER.

All but one replied "No."

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QUES. 6. Can an engineer aid in smokeless firing by the manner in which he operates his engine?

ANSWERS.

All but one answered "Yes," and one answered that the engineer has nothing whatever to do with it.

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QUES. 7. If you are not using the system of smokeless firing, what are your reasons for not doing so?

ANSWERS.

"Different kinds of coal."

"Too many colored firemen and indifferent white engineers."

"We use a system up to date for smokeless firing."—(So. Pac.)

Four replied that they are using their best endeavors to put the system of smokeless firing into effect.

Five roads made no reply.

"Other matters considered of more pressing importance have taken attention, and the average engine man does not take kindly to too many new ideas at one time."

"Do not know. It lies with the General Manager whether any new devices will be tried or not. In case we notice a fireman making too much smoke we speak to him in regard to the matter and insist upon this being discontinued."

"I am burning oil."

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QUES. 8. Do you consider that smokeless firing will be of sufficient advantage, apart from reasons of economy in added comfort to passengers and safety to employes, to warrant its adoption?"

ANSWERS.

Two made no reply and fourteen replied "Yes."

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QUES. 9. Can as good results be obtained by skillful firing without devices as with them? What is your opinion of an arch as effecting smokeless firing?"

ANSWERS.

"Devices are necessary for skillful firing; the arch is an assistant."

"The arch is very beneficial; the only device needed."

"Certain devices will aid skillful firing. We think the best results are obtained when the engine has a fire box and grates of sufficient size and depth to steam without excessive forcing of fire, and when it is equipped with a brick arch, combustion tubes, extended front and proper draft appliances; also, the coal should be properly sized and neither too green or too dry."

"Our experience is to use the best devices offered on the market.

Better results with three or four rows of brick according to the size of the fire box."

"I believe there are devices on the market that if instructions are followed would materially assist the firemen in preventing black smoke. I am in favor of the brick arch, as it causes the gases to better combustion, thereby reducing the black smoke."

"No. Consider the arch indispensible with certain grades of coal."

"No. I think the arch a good smoke preventive."

"There are devices that will aid firing."

"Some form of deflector-plate on inside of door, and the brick or water arch are valuable mechanical assistants to the intelligent fireman."

"The arch is a help in burning the gases and an assistant in reducing the amount of smoke produced."

"I think engines should be properly equipped with this system of firing, also that the arch is necessary for the complete success of the undertaking; however, we have not as yet put them in."

"I could not answer this intelligently as I have never tried anything but the brick arch. There is no question in my mind but that the brick arch aids combustion and is a preventive of black smoke."

"Almost as good. A small quantity of air admitted over the top of the fire from the rear end of the fire box will prevent in a large measure the dense black smoke. A brick arch causes the products of combustion to be a longer time in passing from the fire box, and must of necessity be in contact with the incandescent white flame for a longer period of time."

"I think all that is necessary in the way of a divice for the prevention of black smoke is the brick arch."

"A good arch placed in the fire box in proper place assists very much in smokeless firing."

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QUES. 10. Do you get the same results as to smokeless firing from all grades of bituminous coal?

ANSWERS.

All but one road replied "No." An eastern road replied that they could see no difference in the amount of smoke from the different kinds of coal furnished.

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Next in order is a paper written by a member of your committee on the subject of smokeless firing and best methods, Mr. W. L. Kellogg, Traveling Engineer of the Chicago, St. Paul, Minneapolis & Omaha Ry.

"The phrase is only two or three years old—something unheard of, rarely at least, until the agitation which stated on the B. C. R. & N. Ry., which has caused so much comment, favorable and unfavorable, and claims and counterclaims.

"We say that we have been acquainted with smokeless firing but two or three years. This is because we have known the phenomenon by another name. It was formerly called perfect combustion.

"Perfection is a state or condition rarely, if ever, found among things, or controlled by imperfect man. Consequently we will reason backwards and deduce from the assertions made.

"First: That man and all his productions and actions are imperfect; that combustion regulated by man is of necessity rendered imperfect. If it is impossible to secure perfect combustion, it is then impossible to have smokeless firing at all times under all conditions without the aid of one or more of the smoke consuming devices.

"I had occasion to ride on several engines in passenger and freight service on the B. C. R. & N. Ry. Mile after mile passed without seeing a particle of black smoke. Engine crews with whom I talked all seemed to be heartily in favor of smokeless firing and the one scoop system, and all were vieing with each other to see who could first perfect the new method of firing. There has been a concerted action among the officials of this railway system from General Manager down, ever since its inception. Expense has not been spared. Locomotive coal is broken so that it is not necessary for the fireman to use his pick. Cab fixtures are arranged as conveniently as possible. All engines are equipped with brick arches. Flues are bored out each trip. Strict attention is paid to draft appliances. All the engines are free steamers. Representatives from nearly every railroad in the United States visited this road last year, and I think they all went away with the impression that this company is practicing what it preached.

"The quality of the coal is a potent factor in smokeless firing. The writer last winter made some tests of coal taken from the Des Moines, Iowa, district. It was found to contain 800 pounds of foreign matter per ton. Unless great vigilance is exercised by the fireman firing this grade of coal, to prevent clinkers forming by a frequent movement of the grates, they will, in a very short time, have a heavy fire which will prevent the proper amount of air being admitted to the fire box; under such conditions black smoke is sure to follow.

"By the traveling public and many railroad men, the fireman is thought to be the responsible party for all smoke emitted from our locomotives. While he is one of the principal factors and is often times blame-worthy, it does not follow that he is the only one responsible for black smoke. An engineer can, by careful handling of his engine, especially in pulling out of stations, giving very close attention to boiler feeding, always avoiding too frequent adjustment of the throttle, and by notifying the fireman in sufficient time before shutting off, be of great assistance in abating the smoke nuisance. They should at all times work in perfect harmony.

"The economical load, which is also a factor in solving the problem of smokeless firing, is yet to be determined by Master Mechanics, Traveling Engineers, or some other association, and be recognized as authority by transportation departments so that the locomotives may be designed and built to fill the requirements, with ample heating surface and grate area to insure perfect combustion, provided other conditions can be brought up to something near perfection.

"I believe the one shovel system of firing has aided us very materially in solving the smoke problem. To perfect this system there will need be concerted action from the General Manager's and General Superintendent's office down to the man who coals our engines. The Supts. M. P. & M. and the M. Ms. next to General Managers and General Superintendents are the ones most interested in this subject since their departments and their subordinates are the ones that are expected to try and perfect this system of firing.

"Our M. M. should keep flues clean and tight. Close attention should be given to draft appliances, which in turn insure free steaming engines. This is a vital point in smokeless firing. They should provide tight ash pans with plenty of damper area and well designed grates, which will vary according to quality of coal used. All coal should be broken before being placed on the engine. Close attention should be given to the size of injectors. Quite frequently we notice a No. 9 injector on a 17 or 18x24 inch engine.

"Smokeless firing is then a very hard proposition, no matter how close the engine is worked.

"All engines should be equipped with brick arches, which should be put in properly—say set back from flue sheet not less than six inches. Some one man should be appointed at each round house whose duty it is to look after the brick arches, keeping them clean and replacing bricks when needed. The brick arch is not only a smoke destroyer, but is a coal saver."

"Our M. Ms. should be very careful in their selection of firemen. Brains should be considered as well as the physique of the applicant. Firemen seeking employment should be required to pass a mental examination and have a fair knowledge of the laws of combustion.

"Suggestions made by traveling engineers or traveling firemen should be given close attention by the management.

"Attention should also be given to increased boiler capacity for a given sized cylinder, with proper proportions in heating surface and grate area, means of carrying more air to the top of the fire by being admitted in small jets through a perforated fire box, door liner, and a suitable damper in door. A variable exhaust nozzle that will allow of a reduced draft and a lower velocity of gases passing through fire box, and when engine is working hard giving more time for combustion.

"The compound engine should be and is much easier to fire without smoke than a simple engine, because the velocity of the gases is slower and the steam is expanded a greater number of times.

"With some of the older power, of which most of the roads have a sufficient amount yet to be worn out, smokeless firing becomes a more complex question. Along this line we might suggest that some of the cylinders that have become badly worn and bored out ½ to ¾ of an inch larger than when they were new, be bushed to or below original size. This class of power is that on which some of the patent combustion devices might be successfully applied.

"Feed water heaters, utilizing the air pump exhaust, will improve the steaming qualities of our engines, which in turn, will aid smokeless firing.

"The S. P. Ry. claims that by the use of a patent fire door and the brick arch, black smoke is eliminated entirely. No doubt our friend Mr. Bair, who is from that system and one of the committee, will explain the advantages to be derived from using this door.

"The maintenance of the way-department have a duty to perform in making the profile of the road nearer a horizontal line than we find in many cases, which causes variable conditions in steam making and using, consequently smoke.

"The location of switches, depots and water tanks in sags or at the foot of hills is not conducive to a clear sky or fuel economy.

"The Train Dispatcher is also many times to blame for smoke, but would hardly admit it without protest, as rush orders mean extraordinary steam consumption, also fuel and velocity of gases, which means an extra amount of black smoke, unless engines are equipped with arches or other smoke preventing devices.

"The purchasing agent and coal inspectors are not entirely blameless, and are responsible for smoke. Engines once arranged to burn a certain grade of coal, will not burn another grade equally as well with the same arrangements of draft appliances. So changes in grades of coal used should be few, and different grades on the same divisions avoided as far as possible.

"Conductors and brakemen, especially on freight trains, who have work to do at certain stations on the division, can help out the smoke nuisance by consulting with the enginemen, giving them an outline of the work they will have to do, stations at which they will have to stop, etc.

"Recent tests have proved that coke can be produced from our Illinois and Iowa coals. By mixing coal and coke say in about equal quantities of each, we get an ideal fuel which is free from smoke when fired intelligently.

"The Wooten fire-box with its increased grate area will be a factor in smokeless firing. By its use, combustion need not be so rapid and is nearer perfect. Crude petroleum oil used as a fuel, if ever found in sufficient quantities to supply the demands, will undoubtedly solve the smoke problem, simply because it can be handled with more precision than any other fuel, the supply and demand being equal. It is in a sense automatic if it is atomized by air, and it should be. The oxygen and the hydrogen are so thoroughly mixed with carbon that we get an ideal fuel from an economical, as well as a smokeless, standpoint. The nearest approach to the liquid fuel is the pulverized coal blown into the furnace by air, but as yet has not been used extensively or proved entirely satisfactory, owing principally to the danger from the use of the powder. No doubt the mechanical stoker will take a prominent place in smokeless firing a few years hence.

"Conditions required to cause perfect combustion: Oxygen, hydrogen, nitrogen, carbon and sulphur are the principal elements with which we have to deal in securing combustion, perfect or imperfect. The proportion of each which is required to be in an exact ratio to form perfect combustion

is what makes smokeless firing an utter impossibility at all times, especially in a plain locomotive fire box where the conditions are constantly changing. However, if all concerned, the Supt. M. P. & M. who designs our locomotives, the M. M. who keeps them in repair, the engineers who run them, the firemen who fire them, the traveling engineers and the traveling firemen whose duty it is to see that all things are worked out as intended, all use intelligence and diligence together with experience, we may be able to have a condition bordering on perfect combustion and smokeless firing, which is surely much to be desired."

Mr. D. H. Bair, Traveling Engineer of the Southern Pacific Company, a member of your committee, instead of writing a paper on this subject has referred me to an article embodying all that he could write on the subject. This article was written by the well-known expert on the subject of construction of boilers and draft appliances, Mr. J. Snowden Bell, of Pittsburg, Penn., who recently rode on the engines of the Southern Pacific Railway Company, and his observations were as follows:

"I left Sacramento at 12:50 p. m. February 19, on a train of six passenger cars, one of which was a sleeper, and two eight-wheeled cabooses hauled by a Schenectady ten-wheel engine of the 1800 class, having 20x26-inch cylinders. I rode some distance east from Sacramento in the cupola of one of the cabooses, and was therefore enabled to fully observe the escape from the stack, for most of the time it might have been taken for that of a hard coal burner; there was absolutely no black or heavy smoke, and only a small amount of light smoke when the engine was shut off, or occasionally when firing.

"When riding on the engine up a 108-ft. grade, hauling six cars, I very carefully observed the manner of firing, condition of fire, and character and volume of smoke, and the perfection attained in these particulars was a revelation to me. The fire was kept clear and bright, without either being heavy or having holes in it, and steam was maintained at 180 lbs. during all the time that I was on the engine, and the fire door was never closed. I never saw a soft coal burning engine, either on a level or on a grade, which could be compared as to freedom from smoke with the engine on this run. There was comparatively little smoke at any time on the grade, and even when starting the train on such a hard pull, there was less smoke than I have usually seen in the east on a level.

"The method of light and frequent firing which was practiced is clearly the correct and intelligent one, and in my opinion, involves less fatigue on the fireman than the ordinary heavy firing. The young man who fired this engine did so with ease, and I am informed that they have boys of eighteen firing their heavy engines on the mountains. Without any inspection of records, or facilities of comparison, it is clear to me that they are effecting a substantial economy in fuel, and they are certainly greatly contributing to the comfort of passengers on their lines.

"The small fire door opening was a novelty to me, but is obviously an excellent feature, and this, with the thorough and uniform distribution of

air and support of fuel by Mr. Heintselman's latest design of grate, an effective ash pan, and proper front end arrangements, are clearly the factors to which, with good firing, the results are due. In view of the importance of the subject, and of my interest in it, I greatly regretted that I was limited to the brief observation which I have generally stated above. In my judgment the Southern Pacific methods and appliances can be studied with advantage by motive power men generally who are using bituminous coal fuel, and it will surprise me very much if they are not considerably followed on other systems.

"The kind of coal used on this engine is known as Castle Gate, and is mined in Utah, and its analysis is as follows:

| | Per Cent. |
|---|---|
| Moisture | 2.15 |
| Volatile combustible | 39.10 |
| Fixed carbon | 50.75 |
| Ash | 7.40 |
| Sulphur | .60 |

"Through the courtesy of Mr. H. J. Small, Superintendent of Motive Power of the Southern Pacific, we are able to show the detail drawings of all the mechanical features which contribute to this result, as applied especially to twelve-wheel, 22x26-in. locomotives. The drawings of the stack, fire door and shovel, however, are general and apply directly to more than one class of engines.

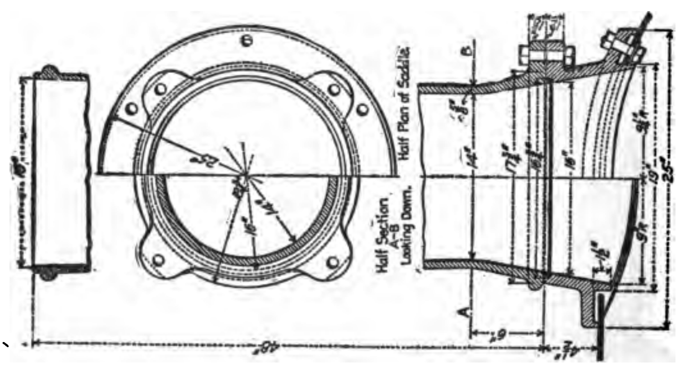


Fig. 1.—14-in. Smoke Stack and Base.

The standard cast iron stack and saddle, Fig. 1, are used on several classes of engines and the results obtained in service are entirely satisfactory. Although incorrect in theory, it has been fully demonstrated that it is really unnecessary to incur the expense of maintaining a special pattern of stack for each class of engines, and as a matter of fact the Southern Pacific has only three patterns of stacks for the entire system, and these have been used since 1890. It will be noted that the stack shown is practically the same as that recommended by the Master Mechanics' Association in 1896.

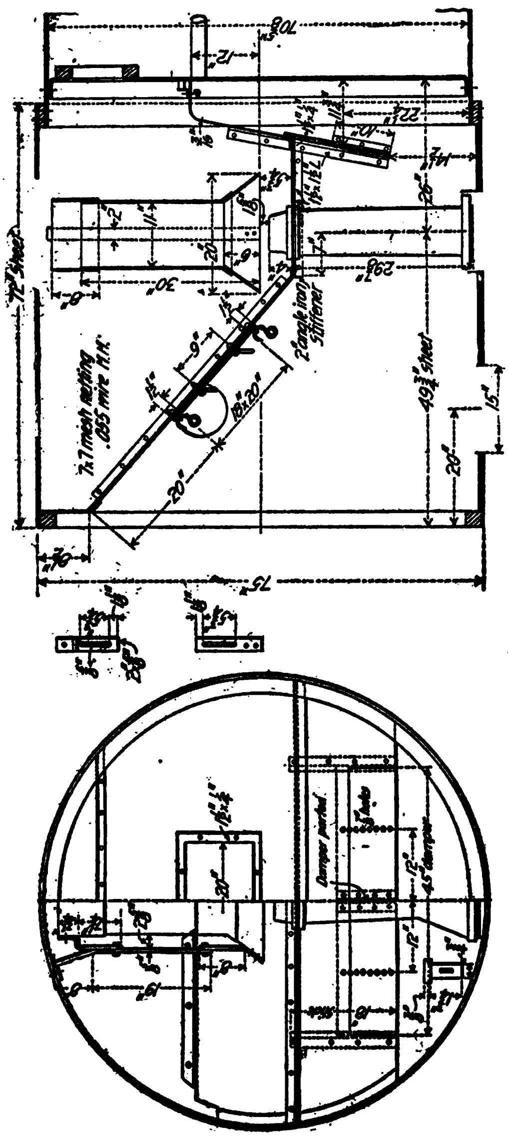


Fig. 2.—Extension Front,

Fig. 2, showing the interior arrangement of front ends, is also practically the same as recommended by the Master Mechanics' Association in 1896,

and is giving satisfactory results. It has been adopted as standard by the Southern Pacific, notwithstanding that it is necessary to use 7x7 mesh netting, and during the dry summer months 8x8 mesh netting in engines running through the valley district. The exhaust pipe and nozzle for the twelve-wheeler class are given in Fig. 3.

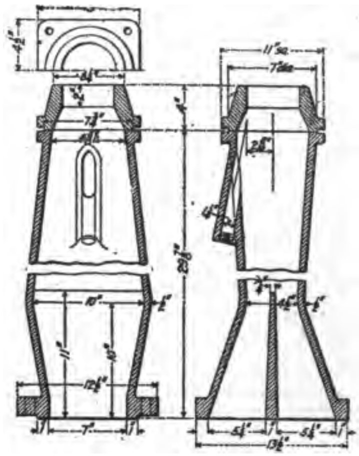

Fig. 3.—Exhaust Pipe and Nozzle.

The furnace door, Fig. 4 (pg. 156), is used on all coal burning engines, the door proper being in two sections. The upper section, commonly called the "trap," is left open continually while the engine is working, and through this opening, which is 6x15 inches for the large engines, the fireman charges coal into the fire-box. It will be noted that the deflector, projecting through the door and opening into the fire-box, is adjustable to any angle desired; it so guides the air admitted through the "trap" as to best aid combustion, and its proper position is determined very readily by the enginemen. It also serves as a check on firing with large lumps of coal, or large amounts of coal regardless of size.

Fig. 5 (pg. 157) shows clearly the arrangement of the brick arch, which is of the ordinary type and needs no special mention, excepting that it is considered an important factor and helps to produce perfect combustion and economy in fuel consumption.

The improved finger grates and bearings shown in detail in Fig. 6 are novel, as is also the manner of hanging the grates from the fire-box sheets. It will be seen that the hanging of the side bars is so arranged as to compensate for the expansion and contraction of the grate bars, and by means of the collar at the end of each trunnion bearing the grates are held central at all times, keeping the air spaces equally divided between the fingers. The air spaces through the body of the grate bar and fingers serve

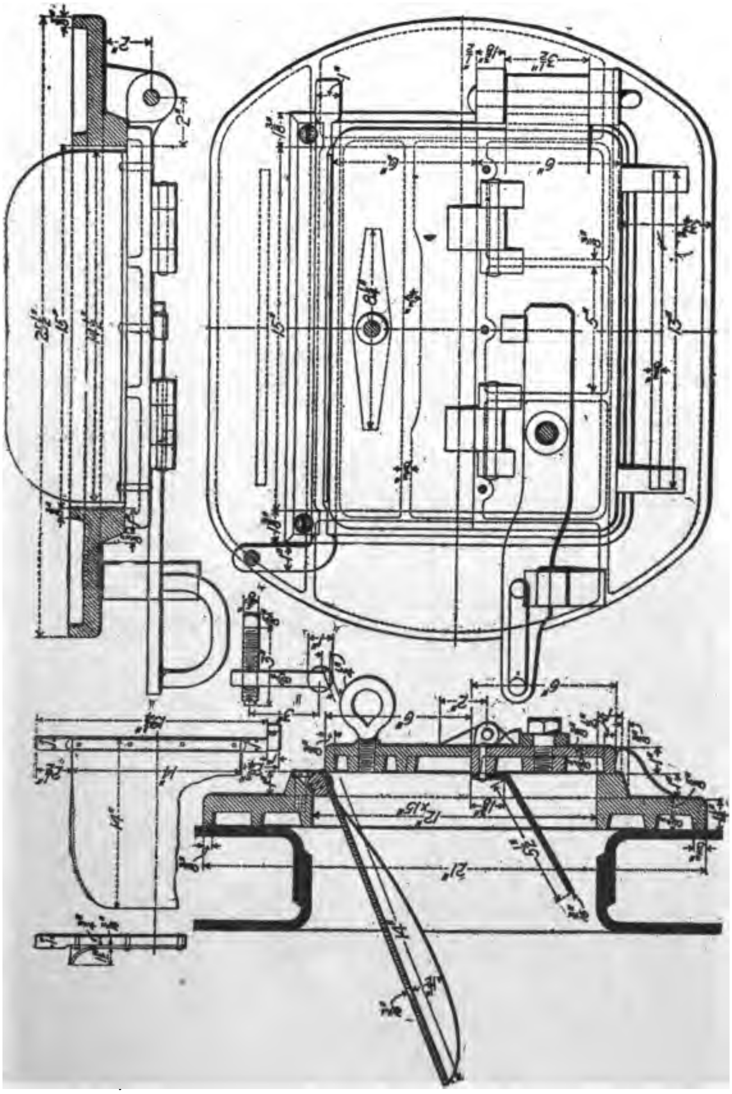

Fig. 4.—Furnace Door.

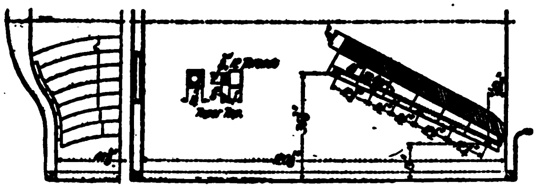

Fig. 5.—Fire Brick Arches.

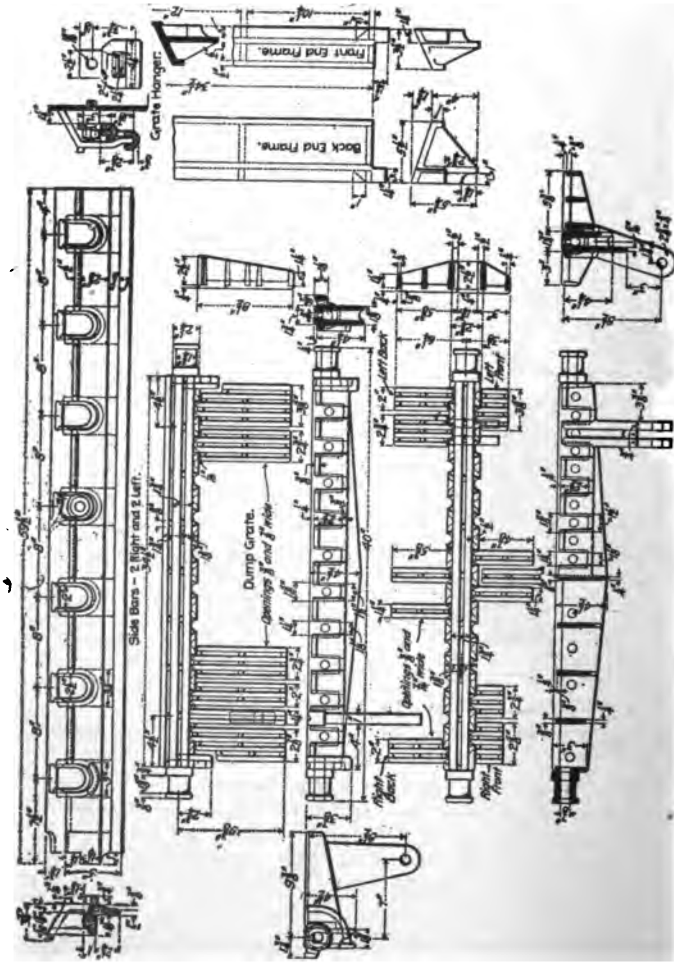


Fig. 6.—Improved Finger Grate and Grate Bearings.

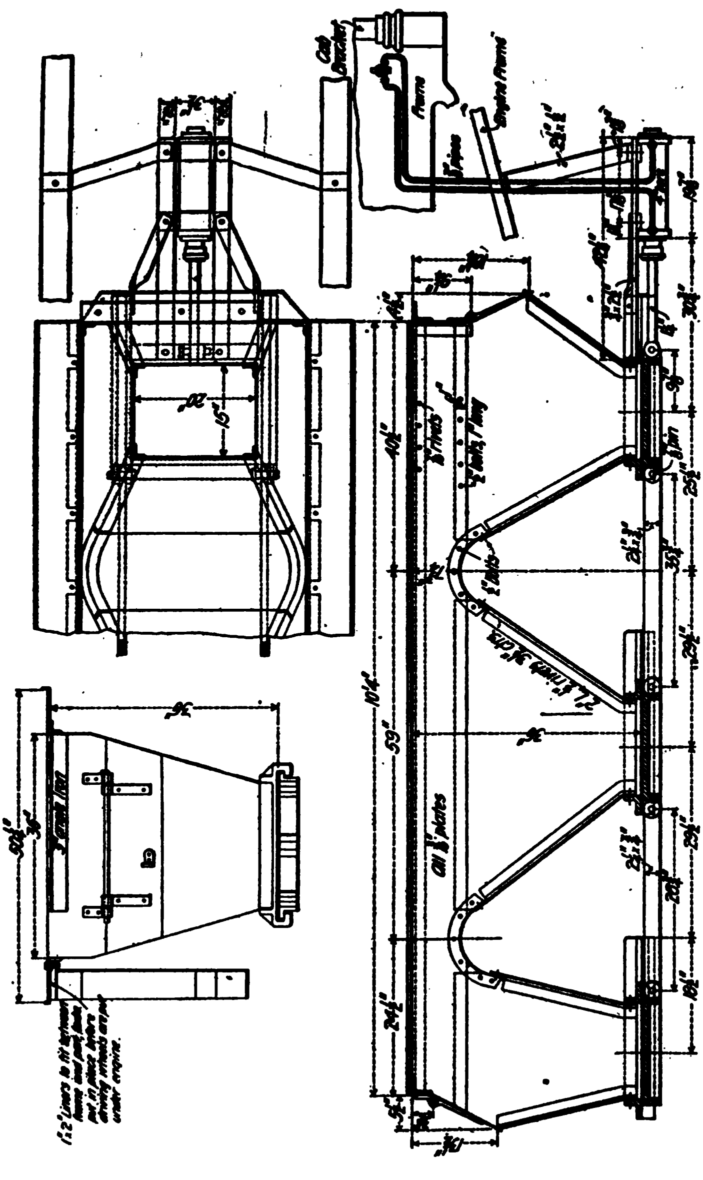

Fig. 7.—Ash Pan Worked by Compressed Air.

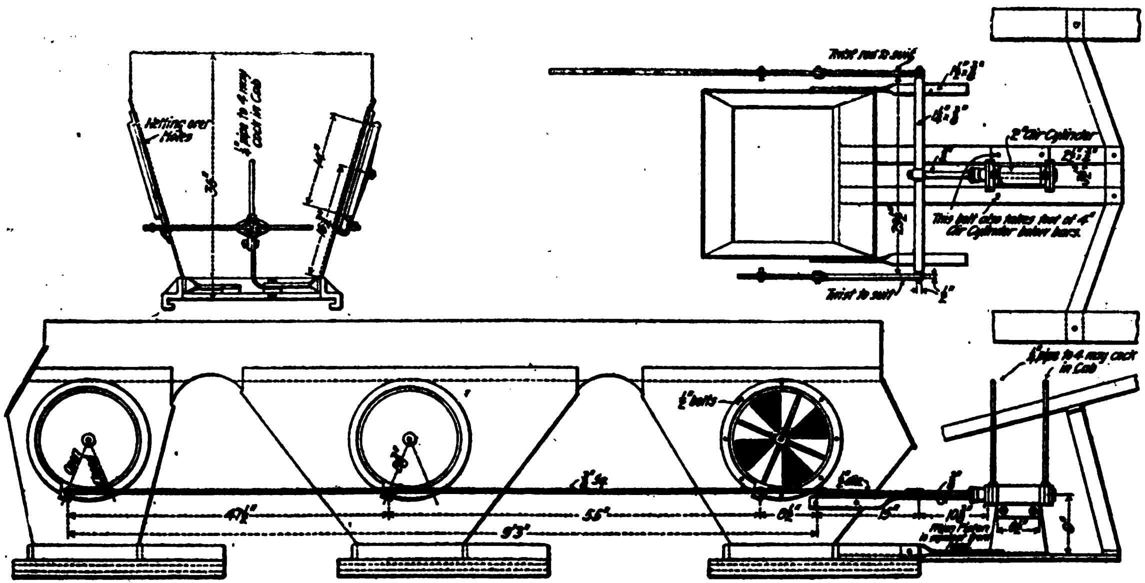


Fig. 8.—Application of Air Valves to Sides of Deep Hopper Ash Pan, Operated by Compressed Air.

to distribute the air to the fire more evenly, and at the same time the thickness of the metal in the body and fingers is reduced to a minimum. The fingers being detachable, they can readily be removed and replaced when change of air openings or spaces between fingers is desired to suit different kinds of coal; or in case any number of fingers becomes damaged in any way they can be replaced, thereby saving the remainder of the grate. The fingers are applied to the grate bars in the rough, or just as received from the foundry.

The general arrangement of the self-dumping ash-pan (adapted to twelve-wheelers) operated by compressed air is shown in Fig. 7 (pg. 158), and the application of air valves to the sides of the ash-pan is shown in Fig. 8; (pg. 159) these side valves are also worked by compressed air. This style of ash-pan is considered an important improvement, and has resulted in a saving of fuel, and a saving in labor and delays to trains on account of cleaning. The side dampers distribute the draft through the grates evenly, whereas, in former arrangements with only end dampers the draft was excessive through the center of the grate and insufficient at the sides and ends. Clinkers no longer form on the sides of the fire-box, and the fireman is always free to shake the grates, knowing that the ash-pan will not become filled up, as the new pans can be dumped in a few seconds by a single movement of a valve. Therefore a light fire can always be carried and there are no delays for cleaning; with former styles of ash-pans where the fireman removed the ashes with a hoe, trains were sometimes delayed on this account as long as thirty minutes. The new ash-pans are so arranged that there is no chance of sparks dropping, and when drifting down grades all the dampers, if required, can be closed with one movement of the air valve, or the openings can be partially closed to suit the conditions.

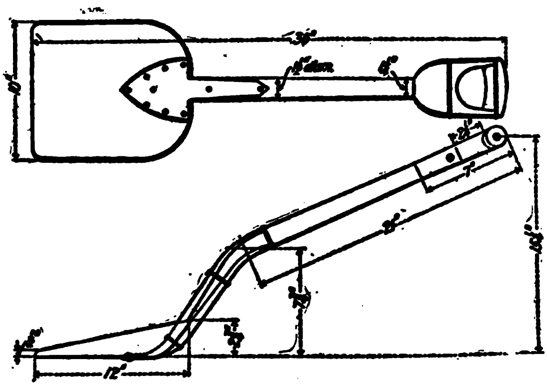

**Fig. 9.—Fireman's Standard Shovel.**

The size of the fireman's shovel is given in Fig. 9, and although it is remarkably small, some of the men make it still smaller by trimming it to suit their individual ideas.

One thing more may be mentioned as in a way contributing to the success of the Southern Pacific in burning bituminous coal, and that is a daily report made by the Traveling Fireman. This is of value in keeping the head of the department posted as to whether the working of firing is being properly attended to. The blank used for this report gives the number of the train, date, names of the enginemen and between what stations the report covers. The questions are well designed to bring out any failures of the men or machinery, and are as follows:

Kind of coal, and was it broken to suitable size?

Was draft on fire properly equalized; if not, what suggestions have you to offer?

Was there any trouble due to clinker or dirty fire? If so, state cause.

How many times was it necessary to clean fire over the division, and time consumed in each case?

If any trouble was experienced for want of steam, what, in your opinion, was the cause of it?

What was the condition of the fire and ash-pan on arrival at terminal?

Was fireman disposed to comply with instructions and practice economy, and prevent black smoke?

Was the general condition of the engine such that would indicate any neglect whatever on the part of the fireman?

Was engine slipped unnecessarily?

Were injectors handled so as to obtain the best results in fuel economy?

Was engine in good serviceable condition? If not, state defects.

The Traveling Fireman is also expected to note on the report or write a letter regarding any other things that may be noticed while traveling or at terminals, that in any way would better the engine service or effect a saving.

A similar report of burning soft coal without smoke was given to the mechanical world by a technical paper in 1898, a part of which we will embody in our report, and it is as follows:

"The writer was invited to come out and witness the burning of soft coal without smoke on a western road. On the morning of my arrival, we went out over a division on a heavy, fast freight train. The speed was limited merely by the capacity of the locomotive, which was a heavy ten-wheeler, 18x24, 180 pounds of steam, and the running conditions were to get to the end of the division as quickly as possible. At first I sat in the cupola of the way-car, which gave an excellent vantage point from which to watch not only the engine pulling the train, but all others that we passed or met. Then I rode on the engine and watched how the firing was done. It was an old story to the writer, for he had been accustomed to the same system of firing in Scotland thirty years ago. But ancient practices with tiny engines had been in this case extended to our modern monsters, and the results were the same—smokeless firing.

The road is undulating, with fairly heavy up and down grades—the worst conditions for smokeless firing—but the physical drawbacks did not seem to defeat the men who were working to operate the locomotives without the emission of smoke.

We went to the end of a division the first day on a freight train, as noted, and returned on a heavy, fast passenger train after darkness had descended over the woods and prairies of Iowa. The writer rode on this engine, which had six cars and was making up time. The process known as "hammering" her was followed, and she went up grade about as fast as the power capacity of the cylinders was worth. My business was to watch for sparks, and the verdict rendered was that this system provided the best spark-arresting appliances I had ever seen. It left the sparks in the fire-box, the place they belong to.

Next day we went on another division, going on a passenger train and returning on a fast stock train. In our two days' outings we saw all sorts of locomotives doing work. There were work engines pulling earth out of cuttings where grade reductions were going on; there were switching engines pulling long and short lines of cars in yards; there were freight engines with heavy and light trains, and there were passenger engines with trains fast and slow, local and express. In all the two days' outing the writer was either in the cupola of a way-car or in some other place where the best possible view was to be obtained of the various engines, and there was no more smoke to be seen anywhere than there would have been had the engines been burning anthracite coal or coke. The evidences of perfect firing were so complete that the results were simply wonderful. The officials and enginemen say that they are going to do a little better when they get more experience with the new system, but I could not see where it could be improved.

The practical results of the improved system of firing are that passenger trains can be run comfortably with the windows open. The company is going to save this year nearly one-sixth of the money paid for fuel last year, and they have done a heavier business than they ever did before. The engines steam much more freely than they did under the system of heavy intermittent firing; the nuisance of leaky tubes has almost ceased; there is no filling up of smoke-boxes with cinders, and there has been a decided reduction in the work of the boilermaker. Last, but not least, the fireman has less work of coal-throwing to do, and he and the engineer are acting together to produce satisfactory results.

The officials of the road are doing all in their power to make it as pleasant as possible for the men working out this method of firing, and every encouragement is given to persevere in the good work. They are putting bell-ringers upon all the engines to relieve the firemen from that duty, and they are putting a low seat in the cab so that the fireman may rest between shovelfuls.

While riding on the engines, I found that the coal was all broken to small lumps, and that the firemen kept up the necessary supply of fuel in the fire-box by putting in a single shoveful at a time. The fire always looked clear and bright and all the engines steamed admirably. The engineer always filled up the boiler well going into a station, and then shut off the injector for a few minutes in starting, to let the fireman make up a good fire. As soon as the train was going the engineer hooked up the engine as far as he could to avoid tearing the fresh fire to pieces. When the engine was

running for a grade, a fairly heavy fire was gradually put upon the grates, and it was maintained during the heavy pull, but was made up by single shovelfuls, or at most, two shovelfuls at one time.

There were no special smoke-preventing appliances used to aid in producing the wonderful results described. The engines all had a brick arch, but no means were employed to admit air above the fire. From January 1, 1898, to October 1, 1898, they have used 104,361 tons of coal, as compared with 114,887 tons for the same period of a year ago, making a decrease for the nine months of 1898 of 10,526 tons. Their train mileage for the same period of 1898 was 2,291,033; for 1897, 2,201,381; an increase of 89,652 miles in 1898.

The coal is obtained from Iowa and Illinois in about equal proportions.

## The following is an analysis of their coal.

| Name of Sample. | Water | Ash | Fixed Carbon | Volatile Combustible Matter. | Per cent. Sulphur. |
|---|---|---|---|---|---|
| Streator (Ill. Coal)........... | 1.45 | 12.71 | 37.44 | 45.01 | 3.39 |
| What Cheer (Iowa)........... | 9.38 | 13.42 | 43.24 | 30.13 | 3.83 |
| Star (Ill. Coal).............. | 10.99 | 12.00 | 47.02 | 27.35 | 1.98 |
| Kingston (Ill. Coal)........... | 9.10 | 18.51 | 40.56 | 29.93 | 1.90 |
| Hanna (Ill. Coal)............. | 9 89 | 21.79 | 34.78 | 29.88 | 3.66 |

N. B. In calculating these results, one-half the sulphur has been assigned to the volatile matter, and one-half to the fixed carbon, in accordance with usage.

Under the old method of firing, all passenger engines were obliged to take coal at intermediate coaling stations; but at the present time the same engines are running from 155 to 250 miles without taking coal. Taking all things into consideration, they save from 2 to 3½ tons of coal on round trips. The size of trains above mentioned is from three to six coaches; engines from 15 x 24-inch to 18 x 24-inch.

"Thorough freight engines on all divisions are 18 x 24-inch, six-wheel connected, and they are fired with one and two shovels to a fire; and it is a very rare thing to see them throwing out black smoke while running between stations, unless it be when train is toiling very slowly over heavy grade. These engines are running from 96 to 105 miles with one tank of coal. With freight trains they are saving from 2 to 4 tons of coal on a round trip. Their trains will average about thirty loads each way over the divisions.

"To make a success of light firing, it is necessary for engineers and firemen to work together. The fireman should carry a clean, light fire, keeping the fire thin enough for plenty of air to be admitted for combustion. This he cannot do if his engineer, in starting, allows his lever to remain at full stroke for a quarter of a mile or more before he begins to cut it back. Under such conditions, the fireman with a light fire would have very little fire left in his box by the time the train had moved half its length. Where the engine is fired lightly and the fire is light and level in the box, the engineer must be very careful when pulling out of stations; he should also be careful when dropping his engine on heavy grades. He should commence in time, and drop his lever gradually. This enables the fireman to carry a light fire at all times, and we must admit that there is nothing so beneficial or so economical on fuel as a clean, low, level fire.

Not only should the fire be attended to carefully, but the water should be attended to, just as closely as the fire. The boiler should have a good supply of water before starting out, allowing the firemen time enough to build his fire and get it in good condition before the injector is put at work. If the water is low in the boiler when starting out, the injector must be put to work at once; the fireman has not had time to get his fire burning well, and the result is that the fire is forced for the first few miles, and probably spoiled for the balance of the trip. The most noticeable improvements brought about by the new method of firing are: The freer steaming of engines; the longer life and more uniform wear of brick arches; the decrease in the number of burned and broken grates; the decrease in the number of bent and broken ash-pan dampers and their fastenings; the fewer number stopped-up flues; the longer life of netting and stacks; the total absence of burned smoke arches and extensions, and the non-accumulation of cinders in front end.

A comparison has been made between the first eight months of 1897 and the first eight months of 1898; the two periods will be referred to as '97 and '98.

"During '97 and previous to that time, the words 'Eng. don't steam' were placed upon the work book from two to four times a day, usually resulting in changing the nozzle, stack or deflector; during '98 the report has been made from one to two times a month.

"On account of the fires being lighter now than formerly, less ash and cinder accumulate on the grate, resulting in the openings in the grates being free from cinders.

"As a smaller amount of coal is thrown into fire boxes now than formerly, and as a smaller proportion of it finds its way out of the stack in form of cinders, it follows that fewer cinders strike the brick arch.

"On account of fires not being so thick as formerly, there is not as much liability to throw coal against the arch. As there is less fire to clean out at the end of a trip, there is less danger of the arch being struck by the clinker bar. For these reasons brick arches last longer now than formerly.

"During '97 fifty-one brick arches were applied to locomotives; the average mileage per arch was 7,863. During '98 one hundred and forty-four arches were applied, forty-five of which have been replaced; the remaining ninety-nine are still intact.

"The forty-five arches have made an average of 9,703 miles each. The average cost, including maintenance, of one arch for '97 was $6.41; an average cost of 8 15-100 cents per 100 miles. The average cost, including maintenance, of one arch for '98 was $4.61; an average of 4 75-100 cents per 100 miles; effecting a saving of $81 on the forty-five arches replaced in '98, and $259 on the total number of arches put.

"On account of the heavy fires formerly carried, and the consequent heavy clinkers, grates were frequently broken when fires were cleaned. The total expense of replacing broken and burned grates in '97 was $91.56; for '98 the expense was $44.30, a saving of $47.26 for '98.

"Before the new method of firing was adopted, large clinkers were invariably formed on the grates, becoming so hard in cooling that it was almost impossible to break them with a clinker bar; as a rule they were forced through the end of pan, eventually breaking the front damper and its fastenings. The expense of repairs on this account in '97 amounted to $23.40; for '98 the expense amounted to $8.20, a saving of $15.20.

"The difference in the number of flues stopped up is almost incredible; formerly there were fifteen to thirty, now there are five to ten—oftener the former number.

"The expense of replacing nettings during '97 was $61.32; for '98 the expense was $33.11, a saving of $28.21. The number of stacks renewed in

'97 was twenty-six, at a cost of $5.23 each; in '98 the number was fifteen—a reduction in this item of expense of $57.53.

"Compared with '98 considerable expense was made in '97 by front ends heating, causing the sheets to bulge and crack. During '98 there has been no trouble of this kind whatever. As no record has been kept of this item of expense, the exact amount saved cannot be given. Fifty dollars is a fair estimate.

"Probably the greatest proportion of expense incurred by the accumulation of cinder in front end was that caused by delays on the road. The report, 'Front end fills up,' is now a very scarce thing on the work book. It usually resulted in front end being opened and adjusting deflector.

"These are the more important improvements brought about by the new method of firing. Those of minor importance are the non-accumulation of cinders in netting, causing delays while cleaning on the road, and occasionally resulting in the loss of hand-hole lid.

"There is now scarcely any occasion for opening cinder-hopper, which formerly resulted in a leaky joint, and eventually in a burned front end and a cracked hopper.

"The front damper rods also made their share of trouble. On account of the dampers being bent, they were hard to operate; sometimes resulting in a broken damper rod.

"These are the direct results of the new method of firing, as no change has been made in any part of the engines from their former equipment, except that all engines are now equipped with a brick arch."

Respectfully submitted,

J. H. Burns, Chairman,
D. R. McBain,
Jas. Grey,
D. H. Bair,
W. L. Kellogg,
Committee.

The President: Gentlemen, we have two subjects, none of the committees of which are here, and it will be necessary to appoint another committee on each subject. One committee on the subjects for discussion in 1901, another is the change in the Constitution and By-Laws. On the committee on subjects we will appoint: Messrs. W. G. Wallace, C. B. Conger and F. O. Miller.

On Change of Constitution, we will appoint: Messrs. D. N. Winegar, Wm. Owens, E. R. Webb, C. F. Schraag and C. F. Keith.

We will expect a report from these committees tomorrow forenoon.

The paper on "What are the best methods to secure good results in smokeless firing" is now open for discussion.

J. A. Baker (A. T. & S. F. R. R.): Although not connected with the Southern Pacific road the method of H. A. Stevens comes nearer perfection than anything I have ever seen; it does not require any practice in firing an engine. At first it worried them to fire through so small a space but it does not take them long to catch on and the engine will do the rest for them; they have a little boy for a fireman that weighs from 125 to 130 pounds. That fireman goes over the road with those engines and does not work half as hard as most boys on the other lines. I have taken green men who have never fired who would fire those engines without emitting a particle of smoke. The deflector feature which is on the door is so arranged that it can be lowered or raised to suit conditions. The prime object is to force the air under the brick arch and the cinders that are taken from the front end amount to almost nothing, they are not large at any time, but they have several conditions in their favor on the brick arch. A set of flues will run three years, on our road they run three or four months, but where you are dependent on lump fuel, the brick arch is considerable of a detriment. Our boys are trying smokeless firing and some of them are bright at the business. I have found that the men that were trying to make firemen of themselves were the men that succeeded in firing with one or two shovelfuls; we have others who would rather sit down and they would pile in coal like a coal heaver. They did not notice much difference in the consumption of coal but they did not do the

smooth work that those boys did. Of course our fire box is nine feet long and those that fire with one scoopful are the ones who did not emit any black smoke. I think the black smoke nuisance can be done away with to a certain extent where everybody helps. I know the engineers can help if they want to, but some are careless and all they think of is their monthly pay check. We were endeavoring to put on one of those smoke burning devices on one engine but somehow it fell through; but I know the Southern Pacific device beats everything I ever saw. It is the invention of Mr. Bates, the master mechanic, and F. A. Stevens, son of A. J. Stevens, the patentees, and they are introducing it on some of the Canadian roads. I think the Grand Trunk is one who is taking it up.

F. H. Nellis: What does it cost to equip an engine?

Mr. Baker: Mr. Bates told me last fall that the first cost was about $25.00.

Geo. W. O'Neal (N. Y. O. & W.): We are using on our road this same device now, we have eight engines equipped with it and it is the best smoke consumer I ever saw; of course our object in getting it was not so much to consume the smoke as it was to get better results; we were up against a hard proposition, the coal we were getting and have been getting ever since was so poor that none of our engines could steam with it. A man who travels for the Brooks Locomotive Works was on our line to deliver a couple of engines to us, and he was telling Mr. West, our Superintendent of Motive Power, about this door and the results that he saw on the Southern Pacific System, and Mr. West ordered one installed right away, and Mr. Dunning came over to show us how to operate it, as he had been delivering a good many engines, and we found by using the Bates door that we made a saving approximating at least 15 per cent. in fuel; the engines steamed first-class and are doing so to-day with the same quality of coal, no change with the exception of change of brick arch; we extended that a little further back and up against the flue sheet. We did not leave any space between the flue sheet and the arch. The engines are steaming good. I am sure that there is not an engine, or any class of engines, that will burn bituminous slack coal, without more or less smoke, but I will say that we found the

smoke nuisance was abated at least 20 per cent., and we consider that a good deal. It is a fact that a great deal depends upon the way the engine is fired in using these doors. The engine wants to be fired regularly and with a small quantity of coal at a time and the fire wants to be kept light. If the fire is too heavy we will have just that much more smoke. We instruct our firemen to fire just as light as possible, according to the condition of work the engine has to do, but I cannot speak in any too great praise of the Bates Fire Door which we are using on our bituminous coal engines.

Mr. Baker: Those doors will burn slack the same as coal. The Southern Pacific is under a heavy expense for coal, their average was $6.80 a ton, they got coal from all over, they got a coal from Washington Territory from a mine they own themselves. They commenced to send the slack down for the boys to burn. The engine burns that just as well as the coal they got from Australia. The only thing is you have to fire light; we cannot carry over 4 or 5 inches or it will clinker on you. The boys have to move the grates often, of course, but if they will fire light there is no difficulty experienced; I know when we were without the door the engines took coal between terminals; with the patent Bates Fire Door we had coal when we reached the end of the division.

G. W. Wildin: I would like to ask Mr. O'Neal if he noticed any difference in regard to the life of the lower flues in the engine they put that brick arch upon, against the flue sheet.

Mr. O'Neal: I will say we have no trouble with leaking flues with the arch against the flue sheet.

C. F. Schraag: Where you use this Fire Door can you use it as well on long boxes as on narrow short ones?

Geo. W. O'Neal: Yes; the engines I speak of have long slender fire boxes with brick arches in them.

C. B. Conger: I do not know as I can add very much to this discussion. In fact I do not say very much about smokeless firing. Locomotive Engineering has gone on record on that subject and I leave it alone. I was at Los Angeles, California, and saw those Bates Doors used on the Southern Pacific engines, both simple and compound, on fire boxes of all kinds, and of course I was surprised to see the men handle so much coal through the

small doors. Engines were coming up hills where it took two big fellows to pull six passenger cars, making 10 to 12 miles an hour. They burn a lot of coal, two to three tons per hour; they had to put that coal through a small opening. I measured one door—4 inches high by 15 inches long, which was on a compound. As to careful firing through these small doors, they make very little smoke. About the only engines I saw making smoke on the Southern Pacific were oil burners and when they smoke they smoke terribly, it makes a thick deposit covering the inside of the flues, they have to put sand in at the fire box door and that cleans it out. I saw them use poor coal and some very good coal on the same engines (not the oil burners), and the engines were all steaming good and as far as I could see they were using coal economically. I asked what they did with the firemen who were used to firing with large shovelfuls; they said it bothered them to find the small door to get the coal in, but they liked it in the end. They do like it. Oh yes, they like it, that is except the door, it is hard to become accustomed to it when brought up to the large opening; they keep the small door open all the time. As far as the deflector is concerned, I only saw two good ones on the engines, most all of them were burned off inside the door; so the action of the deflector I cannot say very much about, but I was impressed with the value of the device, as far as the small door opening was concerned.

Wm. Walsh: While there is a moment's lull I would like permission to mention another subject. The subject in mind is the terrible calamity that happened at Galveston. I believe that our treasury is in pretty good condition and I think we could afford to donate \$25.00 toward the Galveston sufferers, and I therefore, Mr. President, move that we donate \$25.00 and send it as a present of our Association to the Galveston sufferers.

The President: It has been moved by Mr. Walsh and seconded by Mr. Wildin that we donate \$25.00 to be sent to the Galveston sufferers; all those in favor of this, please give the usual sign.

Carried.

Wm. Walsh: Owing to the lateness of the hour I think most of the members are getting tired and I believe there is a boat ride

at 2 o'clock, and I move that we adjourn until 9 o'clock tomorrow morning. This is an important subject and should have all the members present when it is discussed.

E. P. Mooney (L. V.): I second the motion.

Wm. Owen: Are we going to have time to discuss the other subjects?

The President: We have but one more to discuss, and we may have two sessions tomorrow.

The Secretary: Before we close I would like to say that the Arrangement Committee have arranged with the Fire Department and they are going to show us at Engine House No 1 the way they get ready to go to fires in Cleveland.

The President: It is moved by Mr. Walsh and seconded by Mr. Mooney that we adjourn till tomorrow morning. All those in favor will give the usual sign.

Carried.

## Fourth Session.

FRIDAY, September 14th, 1900

President Stack called the meeting to order at 9:10 A. M.

The President: We will continue the subject on "What are the best methods to secure good results in smokeless firing?"

D. M. Winegar (Erie): If any of the members want any change in the Constitution and By-Laws I would suggest they hand them to me.

W. G. Wallace: Mr. President and Gentlemen, I have this to say on the question of smokeless firing. I have found a number of men who claim that they have no smoke, and on riding over their roads I found that they have as much smoke as we do. My experience has been that on most any railroad there are certain runs and engines that can be fired with very little black smoke but not all, and in coming in contact with the expert firemen who claim that they can fire engines without smoke, I have asked for instructions and have invited the gentlemen to come to certain localities,

that we would pay them for their time and pay their expenses and use them well if they would come and teach us how to fire engines under any and all conditions without black smoke. Now the duty of the Traveling Engineer is largely to instruct new firemen, and the time to instruct him is as soon as you can after he is put in the service. I think most of us are trying to have coal broken up and firing done uniformly. In taking the matter up with new firemen, who may be hired from the ranks of bridge or section gangs, and farmers, a good illustration will often do a man a great deal of good. I remember a case in going out with a new man. He said he was awfully green and told me I would have to look out for him. I asked him what he had been doing. "Anything I could get to do." I asked him if he ever worked on a farm. "Yes, sir." "Ever thresh any grain?" "Yes, sir." "Well tell me how they did it; did they get the threshing machine to run just as fast as they could and then throw in a shock of grain at a time and then slow it down almost to a stop?" "Oh, no." "They spread it around and then the horses walked about so fast all the time and the man pitching the grain up to the machine works about so fast and the grain is run out at a uniform speed?" "Yes." "Well now, my boy, I want you to think that you are on a threshing machine tonight, the fire box is a cylinder, the steam gauge will show you the amount of grain you have, and the smoke stack will be the straw carrier that will take away all the smoke from the fire. The engineer will drive the horse power, and the harder he drives the horse power the oftener you will have to feed the fire, but you will spread it in the fire box as near as you can, the same as you would the grain in the threshing machine, and spread it uniformly." Take any of these young men with a little energy, and a simple illustration that they may be familiar with, and they will do pretty well.

I think we have a very bright intelligent lot of firemen on the railroads at the present time; they are studious, they are studying the laws of combustion as far as can be expected of them, they are studying for promotion; and all we can consistently ask from any fireman is to fire his engine according to the laws of combustion, and avoid all the black smoke he can. I do not believe that there are very many traveling engineers who can go on

locomotives and take the shovel away from a man and fire her with absolutely no black smoke; at least I fail to find them, and when we cannot do it I do not feel like asking some inexperienced man to do that. The report of the Committe, I should judge, was largely taken from the employees of the B. C. R. & N. R. R. Now I have never ridden over the B. C. R. & N., but from what I have learned from those who have been over there I find this: That they have not the tonnage rating, their engines are hauling their trains as a rule in about the 9 and 12 inch notch, that the coal is screened and it is furnished by contract; there is no dust in the coal and it is broken up, and if a fireman insists they will screen it over a 4 inch mesh. The B. C. R. & N. is a railroad of 1135 miles; they have 133 locomotives; they have a Superintendent of Motive Power, Master Mechanic and Traveling Engineer looking after 133 engines. We have from 200 to 300 engines on heavy divisions. Now what will apply on the B. C. R. & N. will not apply to a man handling hard and fast traveling on a double track line where the business is heavy and there are different conditions. Now I believe we ought to say to our firemen, "Do the best you can, avoid all the black smoke you can," and when you find a fireman that is making a large amount of black smoke through carelessness where he has opened a damper, jerked the door open, or put on a blower, or done anything of that kind, that is the man we want to go after and instruct. I would like to hear from some of the men who can fire those engines without black smoke under any and all conditions. Now let us look at this: they say we shall put in one shovel full at a time; a shovel of coal will average 15 pounds, in a ton there are about 133 shovels full; in making 20 miles per hour that man would have to put in about two shovels full of coal every minute; very good, he can do that on some runs, light passenger runs and local freights; that man can go along all right and avoid black smoke to a certain extent, but when you come to give that fireman a full tonnage train, start her out on a 150 to 200 mile run, and expect the train to be hauled without any black smoke, gentlemen, you are asking more than you are paying for; you are asking for something you cannot get. You can start out and fire the engine all right for 50, 75 or 100 miles; our fire then begins to get dirty, the fireman will get tired, they

are not going to stand there putting in a shovel full of coal every thirty seconds on the one shovel method. Another thing I find, that in trying to fire engines without smoke, I have attempted to do that on tonnage trains; suppose we are running the engine along on a level piece of track; I know that in two miles from here we are going to strike a hill, now I am firing her with one and two shovels full; the water is up to the top gauge, the steam is up, now I have to build up my fire for the hill, getting it a little heavier. We strike the hill and the lever is dropped a notch or two, at the time the speed decreases the engine is working harder and pretty soon we find that instead of keeping the engine hot the engineer shuts the injector off; well I am only going to put in a shovelful but it is not long before my fire is pulled away and the water is low, and I have yet to find a man who can get out on this tonnage train and handle it with the one shovel method. It is advisable to do so where you can, and advisable to avoid black smoke as far as possible. I think that all engineers do that, but I would not like to see this Association say that it can be done in all cases, unless they are in a position to go out and prove it.

Clinton Decker (M. & O.): The M. & O. adopted this system about eight months ago; they sent me to the B. C. R. & N. to see it. I went there and it is just like Mr. Wallace says; they have the finest coal, well screened, and they have pretty near absolute smokeless firing. I stayed there 30 days, and I got back to the M. & O. and started in there, and we have had good success; but our coal was not screened, it was mine run; the only thing which has helped us is in keeping the fire cleaner, the engine can go 150 miles without having fires cleaned. We do not do absolutely smokeless firing, but we have done away with 75 percent of the smoke.

Wm. Owen (L. V.): We have been using soft coal for some little time. We gave up using hard coal and I find that the engineer has fully as much to do with the black smoke as the fireman. I notice a great many engineers while the engine is going out of a station, doing work or going down grade they let the water get low, then when going up hill they put the injector to work, the poor fireman gets exhausted and the steam goes down; now if the

engineer will keep the water up in the boiler while the engine is hot, I think it will have a good effect. In regard to the coal, I think if the engines are large enough and you have heating surface enough, a good idea is to get a small quantity of pea coal or some grade of hard coal and mix it with the soft coal; you will find it will give better results and make a better fuel; I have found that successful. Of course you cannot regulate the black smoke nuisance with the small fire box as you can with the large one.

Chas. A. Crane (A. T. & S. F.): I was up for a week on the B. C. R. & N. and I want to say that they come very near operating that road without black smoke, and I also have to say that they have some pretty fast trains up there, and to my certain knowledge on one engine at least a train was loaded down so heavy that they had to double the hill, and they certainly have given all railroads an object lesson in regard to doing away with black smoke. On the B. C. R. & N. everybody there from the General Manager down is interested in the black smoke question. They are right in it; the superintendents and train despatchers are just as interested in it as the Traveling Engineer and the Master Mechanic, and by persistent hard work they have educated those men up to the point where they have very little black smoke. When you come to try to put this into effect on other roads, speaking from my own experience, why you are running up against a combination of circumstances that makes it a very hard matter for you to do what they are doing on the B. C. R. & N. They give the fireman every chance in the world; the coal is of correct size, the engineer is held equally responsible with the fireman, and if any black smoke is found trailing over the train or coming from the stack the engineer is called down first. You cannot accomplish anything in the way of eliminating black smoke unless the engineer is held responsible with the fireman, and there is no question but that black smoke can be reduced very much by careful work, and also by the correct drafting of your engines; if your engine is not drafted to have proper action on the fire, you are going to have a hard steaming engine and it will be hard to do away with black smoke.

Mr. Wallace made a remark that no fireman could fire an engine with full tonnage train with one shovel of coal; he is mis-

taken in regard to that, it can be done; we have a fireman on our road that I rode with some time ago with a large train, in fact the engine had more than hard work, she could not get over the hill. That fireman fired the train over the division with one shovel, and he had 180 pounds of steam all the time; it was the best job of firing I ever saw done. I had a record of the number of shovels of coal he put in every time, and he would put a shovel in about every five seconds, and he always had an interval between the shovels, and he fired that engine over the entire division with the engine working at full capacity and had no trouble in keeping up steam to the proper point. Of course that man was an exception, and the engine an especially fine steamer and we were favored with good coal. When you come to take consolidated engines and load them down to their full capacity, why it is a different proposition, but I do not want to see this Association go on record as advocating anything but the reduction of black smoke and light firing. I find when you find a man who is making black smoke, look into it; perhaps he is throwing in two or three shovels of coal; it is simply a matter of being careful both on the part of the engineers and the firemen. I will say this much, if the officials of all railroads were willing to take the position that the officials of the B. C. R. & N. have done, they could eliminate a great deal of the black smoke; but we find it is a pretty hard matter to get them to do that, you cannot get coal broken up, and various other points that have a bearing on the point, and it is hard to get a railroad to look into it, and it is only by putting down all the details, and the engineer and fireman working together that you can reduce the black smoke, and I think this Association should go on record as being in favor of eliminating the black smoke as much as possible, having all the conditions favorable and the material to do the work with.

W. G. Wallace: I would like a little further information; our average scoop of coal is 15 pounds of coal, and five seconds to each scoop would be about 12 scoops a minute or 180 pounds of coal; he would shovel a ton of coal in about eleven minutes, a pretty nice engine. Now it hardly seems to me that our average engine would consume that amount of coal in that space of time without emitting black smoke. It must have been a very good quality of fuel.

Chas. A. Crane: I would like to correct Mr. Wallace; I did not say the engine was fired without black smoke, I said she was fired with one shovel full and the steam kept up. I will say we have a passenger engine running over our road that we have very little smoke from, she is being fired with one shovel of coal at a time. It is hard to get a man who will do that; the firemen as a rule do not like the idea of standing there putting in a scoop full each time. I had an experience with a new fireman; I put this man on for the first time on a heavy freight train; he was firing five and six scoops of coal; I said, "I want you to fire differently, fire with two scoops of coal and see how you do." Invariably when a fireman has been firing with four and five and you tell him to fire with one or two he will have the same interval between the scoopfuls as he used to have; that is where you have to keep calling him down to put the coal in oftener to keep the pressure up all right. He did that for 20 or 30 miles and said he liked it; I said, "Now fire with one scoop full," and he fired right along with one, and he said, "I like to fire that way better than I did the other, it is not so hard on me." I do not take any stock in this story that it is harder for a fireman to fire oftener and light than it is to fire heavy. I think it is easier after they once get into the habit.

C. F. Schraag: The report of the committee shows drawings of the appliances used on the Southern Pacific Ry. for the prevention of smoke. The B. C. R. & N. Ry. uses the brick arch for the same purpose. The engines on the M. K. & T. Ry. all have the plain fire box, and it is claimed that brick arches cannot be used on account of the delay they would cause during the busy season when boilers needed washing out. On part of the line the water is also very bad, causing flues to leak in a short time, and an arch would not be a very desirable thing to have under such conditions. Now while I am satisfied that the use of brick arches saves fuel as well as assists in preventing smoke, we are obliged to get along without them, and I should like very much to hear of something that would benefit us with the appliances we have.

When I began firing I was taught to fire by smoke. My instructor told me to put four scoops of coal in the firebox at one time, then watch the stack and as soon as the smoke began to

clear away to repeat the dose. This plan I followed faithfully for nearly a year, and if any head brakeman on the train I was firing on spoiled it was not because he was not well smoked. The following year I had occasion to take a trip over a neighboring road and most of the time I rode on the engine. Here I found almost an entire absence of the trail of smoke I was accustomed to see; there was also much less coal burned, very little shaking of the grates, and no pulling out of clinkers. The fireman would leisurely put three small scoops of coal on the fire, there would be a few puffs of smoke and then it would be as clear as if wood was burned.

This was something new to me and I watched the pointer of the steam gauge, expecting to see it drop back, but it stuck to the 130-lb. mark as if it was glued there. I asked the fireman how he could tell when the fire needed more coal. He replied, "I watch the pointer on the steam gauge, and when it shows signs of being ready to go back, I put in more coal." When I returned home I tried the same plan with this result: I burned much less coal, was troubled with very little smoke, had no fire to clean, very seldom shook the grates, and rarely cleaned the ash pan. Under the new method I paid in attention to the stack, but kept the dial of the gauge clean so that I could see the slightest movement of the pointer, watched it closely, and as long as it remained stationary I let the fire burn; whenever it made the slightest move backward I put in fresh coal. I soon learned that if I waited too long and let the pointer move back two or three pounds before putting in more coal it would go back still more, and I then had considerable more difficulty to regain the lost pressure, but by putting it in at the proper time I had no difficulty in keeping it up at all times and had no trail of smoke to prevent signals being seen.

The steam gauge should be used for the purpose of telling when it is time to put more coal on the fire, whether the one or three shovel plan is used, but its location on many of the large modern engines makes it difficult and often impossible to do so. They are often so far away from the fireman that the pointer may vary five to ten pounds before he can tell that it has moved. He is therefore obliged to guess when it is time to put in more coal,

and as he is more interested in keeping up the required pressure than in saving coal or preventing black smoke, he will be sure that he does not wait too long and in most cases will put it in before it is needed. A second steam gauge on such engines, located convenient for the fireman, and then have them instructed in the proper method of firing would be a great help in preventing smoke, and would be a good investment on account of the fuel that its use would save.

The engineer also has a great deal to do with the success or failure of smokeless firing and fuel economy. No fireman can succeed unless he assists him. To encourage him as well as the fireman to take an interest in its success there should be a close watch kept of all engines as far as possible and a record kept that will show the interest or lack of interest each crew takes. A record should also be kept of the fuel used; this should include not only the miles run and the coal consumed by the engine, but the engine and crew should have credit for the amount of work done not only in cars or tons hauled, but for the amount of work done in hauling them. If an engine can handle 1100 ton over a division in 25 cars with a certain amount of fuel, and it takes as much fuel, and the engineer is obliged to work the engine as hard to haul 900 ton over the same division in 60 cars they should receive the same credit for the last as the first. Or if on account of weather conditions such as freezing or below freezing weather, opposing winds, speed delays or other causes, the engine cannot handle her full tonnage, although worked to her full capacity, they thould receive the same credit as if they had handled a full train. In other words give them credit for what the engine has to do to handle the train under the different conditions, and not only for the amount of cars or tons hauled. By keeping such a record and giving them to understand that their showing on it in the economical use of fuel and absence of smoke will be taken into consideration when the time comes for advancement, they will be much more likely to take an interest in its success than when the careful and the careless are on the same footing.

The committee's recommendation that care should be taken in the selection of firemen is well worthy of consideration; if intelligent men are not employed we need not look for any improve-

ment. If the committee's recommendation in regard to the condition engines should be kept in by the Master Mechanic, are carried out it will also assist very much in accomplishing the desired result. Badly adjusted draft appliances, leaky flues or steam pipes, grates unevenly spaced or arranged so that they will not shake properly, notches too far apart in quadrant, valves or cylinder packing blowing, or safety valves leaking, injectors too large or too small, will cause smoke and waste fuel in spite of the best engineer and fireman.

I think if the transportation department was also held responsible for the economical use of fuel and prevention of smoke it would be beneficial. If their record depended on the greatest amount of tonnage hauled over their divisions with the least expense, instead of the largest amount regardless of expense to other departments, it might be possible to get a better system of loading engines than is the practice in many places; it might be possible to prevent some of the delays that now exist. Or, as stated by the committee: "To perfect the system of smokeless firing and fuel economy it will be necessary to have concerted action between the General Manager and all Departments. If this is not had there can be no success."

D. Meadows (M. C. R. R.): It seems to me that there are three features that enter largely in the question of smokeless firing, that is the grate and area of heating surface; put those two together and the quality of coal and last but not least the method of firing. We find on the road that I am employed on, that the quantity of coal enters largely in this question. We have one run from Buffalo to St. Thomas, 118 miles, the running time is two hours and twenty-nine minutes; in running that distance this engine usually consumes about four tons of coal and evaporates pretty nearly 6000 gallons of water, now bring that down to tons of coal, the engine will burn nearly 600 tons of coal a month. I wish to say that this engine is fired on the one shovel system, for instance one shovel about every fifteen seconds, that is a shovel of 15 pounds. Now the coal that we use on this run is what we call Erie coal, it is a very slack coal, but has good steaming qualities, it contains a high percentage of volatile matter, being very fine. When the fireman first puts on the coal there is quite a little black

smoke for a few seconds, after that there is a lighter smoke; if he had fired with three or four shovels there would be an intense black smoke all the time or nearly all the time. On the other hand coming from the west, this engine gets what we call our West Virginia coal; this coal contains a larger percentage of fixed carbon and volatile matter. Now with the hard West Virginia coal this engine was fired with what we call smokeless firing, or very little smoke; it was fired on the same system of one shovel at a time. We find more trouble as a rule with our switching engines, we hear more complaints, our switching engines are using what we call Erie coal from the east, and as I said before it has a high percentage of volatile matter; on our switching service the fireman will probably put in a shovel of coal, it takes one or two seconds to dry it, and naturally there is black smoke, you can scarcely avoid it. I am entirely in favor of the one shovel system of firing, and never more than two.

J. F. Walsh: Relative to smoke on switch engines I wish to say from my observations on some parts of the Louisville & Nashville road that they have overcome that matter by using coke on their switching engines; they use it and use it very successfully; they have their engines regulated so they have no trouble, and if any of the members wish any information on that subject it undoubtedly can be had from Mr. Leeds of the L. & N. They have worked with it very successfully and satisfactorily, and where coke can be gotten cheaply it will help to do away entirely with this matter of smoke.

Geo. H. Horton (M. St. P. & S. S. M.): I was on the B. C. R. & N. and I found they were doing all they claim to do and with all kinds of trains, fast, slow, light and heavy trains, I rode over their road on, I think, every train they had, and I found without exception they were firing without black smoke. I returned to our road and commenced by consulting some of the best men, talking with them and teaching them how to fire; I had as much trouble to teach the engineer as I had to teach the fireman. I found they were equally incapable of doing their duty in regard to this black smoke nuisance, it rests equally with the two. First I want to say that the engines are not equipped with any devices, some have brick arches and some have not; it does not

make any difference about the engine, we aim to do the same kind of work with them all, but that you cannot do. The engines equipped with brick arch consume all gases, therefore you do not have the black smoke; the larger the engine the more surface in the fire box and the less black smoke is emitted; I find it very difficult to fire small engines with small fire boxes without black smoke, and to tell you that we have none on the road would be saying something that is not right; the quality of coal we have cannot be fired without some smoke. We teach our engineers that it is bad to keep their fire up when the engine is not in use, therefore standing on a side track we let the fire go down and when the fireman gets ready to work, he builds it up freshly, if the conditions warrant; if not and they are ready to go out he puts anywhere from one to three shovels of coal, as the conditions may warrant. The coal we are using is the grade we get from Pennsylvania, although we use some Virginia coal. With the Voughougheny coal we use I find we can fire with less black smoke than we can with the Virginia coal, for the reason that the Voughougheny will produce more steam with less fuel, I should say fifty per cent. more; the Voughougheny coal is a fine steaming coal, but with the Virginia coal you have to use so much that the fireman is continually putting in the coal. The B. C. R. & N. is using coal that they get in Iowa and Illinois. Their kind of coal does not produce the black smoke that the Voughougheny does. It was taken from the mine and was broken up ready for the fire. I endeavor to have our coal broken but it is not always done, yet the fireman is instructed to break the coal. I prefer that he fire with one scoop at a time, but he cannot always do that and break his coal.

Wm. Owen (N. J. A. B. Co.): I do not wish to consume any time, but I fully agree with Mr. Schraag in relation to the steam gauge where the fireman can see it, but in addition, to that I will recommend some way for the fireman to know where the water is. I have noticed that on a great many types of engines there is no opportunity for the fireman to know where the water is; the engine only has one set of gauges. Now I contend that it is just as necessary for the fireman to know where the water is as for the engineer, to economically work the fire. Furthermore, if possible, I would recommend assigning regular engines to regular

men, and if that is not possible I would be in favor of recommending keeping engineer and fireman together, for when they work together they learn each other's methods; and I think in following this method out, that outside of avoiding black smoke you will save ten per cent. in fuel.

Martin Monroe (C. O. & G.): I have always had it in for the man who invented this question or smokeless firing, and I think he must have found out by this time that it cannot be done. A great many people say it can, and that they do and have done it, and that they do it on the B. C. R. & N. Well, the conditions favor all those things, but we keep right on making black smoke. Now for a sample I want to refer you to the time when the letter regarding black smoke came out in the "Locomotive Engineering." I read it over and handed it to the Supt. of Motive Power. He did not pay any attention to the coal, he did not pay any attention to the front end, he did not pay any attention to anything, but he sat down and ordered copies for every fireman on the road with a letter accompanying each copy saying that he wanted them to fire without making any black smoke. He sent a representative to the B. C. R. & N., he came back and said they did it. I do not doubt but what they do, I have no doubt in the world but what they have found the conditions to do it, but their engines are fixed to do it, they have the coal to do it, and now then without those things you cannot accomplish it. There is coal that will make black smoke, there are firemen who will make black smoke and there are engines that will make black smoke in more places than the stack. (Laughter). We have had a great time trying to fire without black smoke. Now then, the fireman puts a little bit in at a time, I did as little firing as I possibly could, and I make as little smoke as I could because I would sooner fire with one shovelful than with two or three. I do not think we have a fireman but what would sooner shovel in one than four if you have fixed the conditions to make it possible for him to do so, but you want those trains on time and they want you to get there, and we do—and we make black smoke. I was going to say we tried it on the D. R. & G. I have had two or three firemen who could fire making very little black smoke, with my help, but it is a hard proposition when you burn four and one-half to six tons of coal

in 52 miles, and I do not believe it is a success—that is getting rid of the smoke. I would like to call your attention to the fact that I believe there is one thing that is absolutely necessary for the Traveling Engineers who take an interest in those things, that while they travel a great deal on their own line they do not travel enough to see the things in other places. When I left the D. & R. G. I went down in Arkansas; it was a new country, new people and new engines to me, and I found all kinds of conditions. I found that the firemen could not make any black smoke with the coal they had. Now that is a fact and it is the coal that did it. I will guarantee that there is not a road in this country or a locomotive equipped with the extension front end or the diamond stack, or any other way, that will smoke with the coal that they use in Arkansas. You cannot make any black smoke because there is none in it. I would never have believed this if I had not been there; it is a positive fact that coal was gotten in the state of Arkansas, and without a doubt it is the best coal I ever saw. I do not know what the preparation of it is, but I know it is a peculiar sort of coal, and the firemen who know how to handle it best would sooner have the slack than the lump coal. That is a very rare thing.

We had two engines from the Rogers Locomotive Works in passenger service. I rode with them a great many times. They were 18x24-inch cylinder, four to seven cars, and they went over the division both ways without making a particle of black smoke. They used from four to five tons to make the round trip. In July I tested some coal from Nebraska on a freight engine; it was a peculiar lot of coal, but was nice looking. I made two trips on passenger and two or three on freight, making the round trip—one way 196 miles—and I tell you that the steam gauge did not vary five pounds at any time over the road, and at the end of the run there was not over two or three inches of fire in the fire box; if the engine had stood for 30 minutes the fire would have been out. Another thing in connection with that coal—I know it is the best coal in the country, for the reason that it makes no black smoke, throws no cinders, and I am safe in saying you could run an engine 10,000 miles without cleaning the fire.

John McKenzie (Nickel Plate): I hardly know where to

commence. I am a good deal like the gentleman who last spoke; I think that when a man can cover the grate surface of a fire box 11 feet long and 5 feet wide, he is too good a man to remain in that position. In regard to the absence of black smoke, I found on our line that the greatest trouble we had was in educating our men to have their fires in good shape before coupling on the train. Some time ago in conversation with the officers on our line I took up the question of why it was that trains due to leave at 10:01 did not leave till 10:04 and that trains due to leave at 10:10 did not get away on schedule time. Then the question was taken up that the fires must be properly built up and in condition, so when the time comes his fire will be in readiness to pull out, and we have given orders that we want fires in condition, and I think that is one of the greatest difficulties we have, to educate the men in getting their fire in good condition.

I noticed one thing in this report, that is the answers to question 6; all answered "yes" with the exception of one man; and that one answered that the engineer had nothing whatever to do with it; and talking about firing—I think the best thing to do is to fire that fellow right away. Another thing in question 7; "Too many colored firemen and indifferent white engineers." I hope that is not so. I remember some time ago when the compound engine was being run throughout the country; one of them going down on the L. & N. with Pulaski Leeds, the results on that compound engine showed something like 32 to 35 percent fuel saving over the simple engine they were using there; I made some investigations and said to one man, "What is the matter with your power?" he answered, "Colored firemen and indifferent white engineers." These compound engines are sent out with skilled firemen and the man on the right hand side of the engine is trying to earn the money we give him every month, and I think that goes without saying. I want to say now that the matter of economical, smokeless firing lies entirely in your hands and you can not get too close to the Master Mechanic or Superintendent of Motive Power on this question. The train dispatcher has a good deal to do with the black smoke, I think. That question was taken up with us about the same time as getting out of the station on time; a man on the side track with an order to meet a train, of course

he is going to let his fire go down; he gets his orders changed and has to start out in a hurry, he always gets as much coal as he can into her, and water, possibly, at the same time, and there you are; you have to run probably 50 miles before you can get your fire in proper condition to run it economically. I would like to say a good deal more but I do not want to take up the time, Mr. Chairman, only I know I am talking to a body of men who know their business, and I look forward to this Association being of a great deal of value to the Master Mechanics and Superintendents of Motive Power of our roads, and there is no man I know of who can better earn his money or give better satisfaction than the Traveling Engineer.

D. Meadows: I would like to say for the benefit of Mr. McKenzie that while we practice the system of one shovel firing, we do not try to have the fireman cover the whole fire box with that one shovelful, we admit that would be an impossibility. Our firemen put in coal the same as if they were going to put in four shovels; they put it in first on one side then the other, and I believe the smoke nuisance will be reduced greatly in this way. I think the points that Mr. McKenzie gave us are very useful suggestions for us to take away with us. I think it is the proper thing to have your engine in shape before you start out, and the advice he gives us is well worthy of our consideration.

J. V. Murray (C. B. & Q.): I take it that this Association wants to arrive at the conclusion that firing with one or two shovels will be best and overcome the black smoke. We have been trying for months past to get rid of it as much as possible; we find the greatest factor in getting rid of black smoke is a properly gauged brick arch; we find that this arch does not cost anything, that it more than pays for itself and the putting in, in the saving it makes in fuel the first round trip over a 125 mile division. We are getting some of our firemen, who have more intelligence than the average run of firemen, so that they get along with very little black smoke. We use a very smokeless coal as a rule.

Eugene McAuliffe: Regarding smokeless firing, a great many Master Mechanics have simply made use of that on the "Go thou and do likewise" plan, not satisfied to lead. I find the average engineman is willing to follow if he can find a proper

leader to follow. A great many Master Mechanics bought a number of copies of Locomotive Engineering and put them in the hands of their firemen and told them they expected the same results as the B. C. R. & N. got; they did not do anything for their engines, made no effort to improve the mechanical conditions of the power or to select the coal; just simply expected by circulating those pamphlets and papers to bring about this accomplishment. The average man is willing to follow a good leader, and the first thing required is to get the power in proper shape to burn coal without smoke and burn it equally; we can insist then on the enginemen doing their part; we cannot insist on their doing their part until we do ours. Of course many conditions influence this black smoke question. Leaky steam pipes and exhaust pipes; those things affect to a greater extent than we are aware of. An engine will commence to fail in steam, the condition becomes worse, the engineer complains and he will eventually lose heart; probably those men after five or six efforts give up the struggle, simply because the man at the head is not able to do his part; those men cannot do everything they would like to. This question of economy and smokeless firing has to be handled by the President and General Manager and the word passed down the line to the fireman. Traveling Engineers, in my opinion, ought to be Train Masters; I never could understand why an engineer could not perform the duties of the Train Master just the same; they are closely related to the manipulation of trains, and it seems to me the Traveling Engineer should be a Train Master; at the same time I believe those offices should be conditioned. It takes a man of considerable capacity to handle 600 or 800 enginemen, as is the case on several roads in this part of the country; I know one Traveling Engineer who has 650 enginemen to handle; they simply must keep up with the times; he cannot keep up if he labors 18 hours a day; that man working 18 hours a day is always three to four days behind; he is an officer of this Association; he is not here, he is working, and he could not spare the time to attend this Convention.

Speaking on the subject of quality of coal, railroad officials will tell you that the coal question is an uncertain quantity. You never know when a strike is going to come on and effect a short-

age; it is necessary to keep a supply of coal; stored coal slacks some and it is very difficult to fire with; the average quality of soft coal slacks after it is mined two or three months, and we get our sheds filled with that, and when their trouble is over they go back to work; we go into those sheds and take out that slack coal, and the men get discouraged firing with that coal for months; that is nothing the railroad official can control, but it is a big feature in this coal question.

On the steam gauge question: I rode on an engine the other day; the fireman had to get up in the cab and climb up half way over the engineer to see the steam gauge. I believe in having a separate steam gauge for the use of the fireman; I could not fire an engine without seeing the gauge and knowing where the water was. Another thing, the question of putting an engine in condition; as far as the cab is concerned, the engineer is responsible to a certain extent. A great many people may think it is cheaper to operate an engine without cleaning; they think the money spent in cleaning an engine is wasted; people say she pulls as many tons with her dirt as she does without it. I question it; I am firm in the belief that an engineman can haul more tonnage with a clean than with a dirty engine; he will take more interest in his busiiness. You have to keep the tone up; if you cannot keep your enginemen properly toned you cannot get good service. I would recommend to Traveling Engineers and Master Mechanics that they do their part first, then I believe in insisting on engineers doing their part, and you cannot do so until you have done yours.

Mr. Long (N. C. & St. L.): I had advice from our Agent to go over on the C. S. after leaving the Convention at Cincinnati. In regard to smokeless firing, I went over there and they were doing about what they claimed to do, with a certain grade of coal on their passenger engines. They had a French arch in their engine and it was very little smoke that the coal made; when they got bad coal they made more smoke, and as the gentleman has said before, the engine has got to be fixed in proper shape to get along without black smoke. The fireman put in one scoop of coal and he shut the door against the end of the catch, he sat there about two seconds, then he closed the door, and while the engine was working he put in another scoop of coal, and that is the way

he overcame the smoke. I went back to our road and I can safely say we cut our black smoke down fully one-half. We use brick arches, but we do not use the air flues nor the French arch. It has been said before, certain coal that we get, with the proper assistance from the engineer, will help out greatly in reducing the smoke. Smoke is a non-conductor; I suppose you have noticed it a great many times that in an engine that steams bad you will find a black fire box, you will find the front end fittings all gummed up; engines that steam well you will find a fire box nearly light and you will not find the front end all smoked up.

Eugene McAuliffe: One question I think that Traveling Engineers should nevertheless stick to, and that is the matter of keeping on engines enginemen of congenial temperaments; I am not speaking of tempers as applied to correction of family troubles, but I believe that when engineers and firemen fail to get along, the Traveling Engineer should separate them; a great many Master Mechanics discourage that because they believe in making men get along. I believe that engineers and firemen should be satisfied; you never get good results unless they are.

Mr. Benjamin: I suppose you were the first engineers to come to the city of Cleveland and that you suppose from what you have seen that there is no department of smoke, but I must tell you that it has been in existence for only two months. I can perhaps return the compliment by saying until I came to this meeting I had no idea from what I had seen on the roads that the question of smokeless firing had ever come up before any railroad organization. (Laughter).

The reason why I have been very much interested by the report of the Committee which I heard yesterday and by the following of the discussion which has taken place this morning on this subject of smokeless firing on locomotives of course is that it applies to our needs. All citizens of Cleveland are very much interested in the subject locally. I find that it is advisable to a greater or less degree to abate the black smoke in the case of locomotive firing as well as stationary firing; I have been told repeatedly that that was not the cause, that it was largely blamed on the railroad, and I am very much pleased and encouraged to learn that engineers still believe it can be done. We have no possible hold on the rail-

roads, they are regulated by some inter-state law; all we can do with the railroads at present is to consult with them and try to interest them in the subject and to have the smoke reduced within city limits the greatest amount possible. I believe that stationary engineers should come into this meeting and learn a great deal in regard to firing. I notice in many of the engine rooms which I visit that there was a tendency among the firemen to put in as much coal as they can at one time for the sake of the 15 or 20 minutes interval for sitting on a keg outside the door, and there is a great temptation to do this. I have been trying to impress upon them to put in less and at short intervals, and I think if they could have heard what has been said here this morning, it would have a good effect. To abate the smoke, the first thing to be done is to attend to the locomotive and stationary engines, as well as the proper machinery; I have had the matter up with some of the General Superintendents in this city, and although I have just made a beginning, I am going to try and begin at the top and take up the matter with the General Managers, S. M. P's., Presidents, and then work down, and I am convinced from what I have heard this morning and yesterday, that there is no friction in a body of men who are so well fitted by training and by circumstances to help along in this work as the Traveling Engineer; they are just in a position to reach, perhaps, the main influence. In closing I want to thank you for the privilege which has been given me to speak here this morning, and would say that I would like to meet personally every Traveling Engineer of roads with terminals in this city and discuss this subject with them, and I ask the assistance of all such engineers in this locality, and I hope that they will take the trouble when they can, to come to see me at the City Hall or make an appointment with me in some way, so I may have their assistance in furthering the work in this locality. You must confess there is very little encouragement in doing anything of this kind, but I want to say to you that the department is growing and within two or three years there will be considerable improvement; it will be slow but sure. The subject has been taken up with the railroads, but very little attention has been paid to it by those high in authority, and it is only necessary to push this along in these lines and at once it will make a great improvement in the city.

C. B. Conger: I do not believe you can handle these big engines properly unless the steam gauge is where the fireman can see it. If the engineer needs one give him one; give the fireman the first gauge and give the engineer the auxilliary gauge, same kind for two places; one up in the middle of the boiler for the engineer and the other on the fire box for the fireman who really needs it; there is a point which I do not think has been brought up about the firing with the one shovel system. We tell the fireman he must fire at regular intervals and he must have his fire ready to pull out, and to do this with one or two shovels of coal; the train rules have something to do with this and with his work on a locomotive in the way of looking out for schedules.

J. F. Walsh: Taking up the matter just spoken of; there are 25 large consolidated 22 x 24 inch engines on the C. & O., they call them the G-6 engine; those cab fixtures are just as handy as they can possibly be on any engine. I understand from Mr. Morris, Superintendent of Motive Power, that before the specifications of those engines were sent out the mechanical men were called in at Richmond, they were shown the specifications and were told they were about to be asked, as far as their part was concerned, for suggestions relative to the convenience, and those big engines are just as handy as they can possibly be, just as handy as in a small engine; there is the steam gauge, there is the throttle and the reverse lever, and the injector, just as handy as on any small engine I ever saw, therefore I would say again that it is an excellent idea to have a general expression of the convenience from the men interested in the matter, and advise calling in your engineers.

Now, Mr. President, while I have an opportunity I want to suggest a thing or two. Our motto is to improve the locomotive service on the road, anything we can do ought to be set down in the minutes for the purpose of enforcing our motto. In the first place, my idea of the matter is, that the Traveling Engineer should be to the Master Mechanic or Superintendent of Motive Power, what the train master is to the Superintendent; it is a common thing to find them so busy with correspondence on their desk that for days they are unable to take up anything of a real mechanical nature; they are not in touch with the motive power

department, they are not in touch with the Master Mechanic or Superintendent of Motive Power, consequently after a few months trying in that way, they lose interest in the matter of mechanical features. Now I believe that Road Foremen of Engines or Traveling Engineer should be very close to the Master Mechanic or Superintendent of Motive Power and be kept such.

Beyond that we have been discussing the matter of smokeless firing. A circular is sent in from one road or another, a man is sent out to observe the practice on some road who has made a success of it. He comes back, gets out a circular, sends it to his enginemen saying, you must do likewise, I have seen so and so do it and it must be done here; they do not take the engineer into their confidence, they do not get these men together and explain how those things are accomplished. You have troublesome engines, either from steam, smoke or other troubles; there is a cause for all those things. My idea is, get down to the cause of them; if you have a hot journal, there is a cause for it; take the engineer into your confidence and when you have discovered the cause of that trouble call his attention to it, bring him over to it and say, here is where the trouble is; not keep that man in the dark.

Let me suggest something that has occurred to me at this meeting; that we ought to advise men in charge of the different terminals of railroads at the point at which we hold our meeting, that these meetings will be open to engineers and firemen, they will be welcome here. This will make them study; this is my home city and I have been busy inviting them to come here, they say: your meetings are secret. It is not generally understood that our meetings are wide open to any one that is interested in our subjects; now I find that railroad men are willing and anxious to learn and once they have listened they take an interest in it, but when you undertake to drive men the same as you do a machine, their natural prejudice comes up. Let them come in here, let them listen; let them hear what we hope to accomplish, how we hope to accomplish it and by that means we will probably improve the service on American railroads more than by any other means. We would explain to them our devices and let them go into the matter, investigate for themselves; but if you simply take the position that this *must* be done, regardless of the local conditions

that exist, you prejudice your case right from the start. Get the conditions right first, get these men with you and immediately improvements are seen. Now I speak from experience; I travel and come across considerable of this trouble on railroads and I say to you that my experience has been that the disposition of our enginemen is usually good, help them, show them and explain to them and by this means you get them with you. I would suggest to the Association that hereafter when we meet at the different terminals of railroads that we send out an invitation to the engineers and firemen to attend our convention, so there will be no misunderstanding; engineers and firemen are invited and welcome to our meeting. It will not only be useful to them, but it will add largely to our membership a class of men who will do us and the railroads good.

The President: A motion will be in order that a Committee will be appointed to make some recommendations in regard to smokeless firing.

F. M. Nellis: I think this will be a very good subject to be carried over another year. I think this subject should be continued; I think it would be beneficial to the Association and railroads to have it carried over and gone into more thoroughly, and make some more substantial advice to the men in general as to what should be done to overcome the conditions; we have been relating conditions this morning, now advise the way to overcome them.

F. O. Miller (C. H. & D.): This subject is in its infancy; this question has been brought up by the B. C. R. & N. and I, like several other Traveling Engineers, have been on the B. C. R. & N. and have seen how they do it and it should be handled very carefully.

The President: Gentlemen what is your pleasure on this subject?

F. M. Nellis: I move that the subject be carried over another year.

J. V. Murray: I second the motion.

Carried.

F. M. Nellis: I move that the report be accepted, the discussion closed and the Committee discharged.

C. B. Conger: I second the motion.

Carried.

Mr. Long: I make a motion that the Traveling Engineers recommend one scoop firing as far as practicable.

Chas. A. Crane (A. T. & S. F.): I think that motion should be worded differently; instead of saying "one scoop" say, as light firing as possible.

Chas. H. Hogan: I think we make a mistake in recommending one shovel firing, the conditions are so different all over the country, the abating of the black smoke nuisance depends largely on the quality of the coal, good judgement of the fireman and engineer and the drafting of the engine; a man can fire and not allow much black smoke to come from the stack and fire two or three shovels at a time. I do not think it would be advisable to recommend the one shovel method of firing to go upon record as doing so; you all know the results of the last recommendation throughout the country and we do not want to antagonize our firemen and each man can handle his own men and encourage them to abate the nuisance working under the conditions in keeping with his road.

F. M. Nellis: Inasmuch as the subject is to be carried over another year under another heading, we are going to find out more about the question. I think it wise for this Association to say nothing definite on this head; next year we can make a better recommendation than we can now.

C. B. Conger: Any resolution coming up that says use the one shovel method of firing without first fixing the engine, getting the right kind of coal, providing the engine as they should with proper drafting and proper size of coal, I am going to vote against it.

The President: The chairman on Constitution and By-Laws would like to have the members of that Committee meet him outside of the Convention Hall.

The President: The next paper to be discussed is "Tank Valves, Goose Necks, Hose Strainers and Suction Pipes on New and Old Engines." Mr. Gillett will you kindly read this paper.

Mr. Gillett then read the report as follows:

## Tank Valves, Goose Necks, Hose Strainers and Suction Pipes on New and Old Engines.

*To the President and Members of the Traveling Engineers' Association:*

GENTLEMEN: Your committee on the fifth subject to be considered, submits the following report:

Circulars were sent to all members of the Association and others; we are sorry to say that on such an important matter only nineteen replies were received; out of this number three were members of the committee, so our report is based upon these replies and our own personal experience.

We said the subject was important and we believe it to be the most important factor in the operation of our locomotives; each part has its own responsibilities, yet without water all are at a stand-still.

The questions handed your committee are as follows: Tank valve opening, goose neck, hose bag, strainers and suction pipe. The questions were left open and broad; we have many different styles of injectors and kinds of water to contend with, the conditions being diametrically opposite as to location. The conditions suited to one part of the country would be a complete failure in another, and in order that we could be placed in possession of such information from all points, and through that be enabled to make such suggestions that would benefit each and all concerned, the questions were put in such form as we thought would bring forth the information sought.

If we succeed, by any recommendations made, in bringing out the desired result, viz., the improvement in the service mentioned, or by criticism at this meeting, we will consider we have done our duty and conferred a blessing upon those who have been afflicted. We sincerely trust that any recommendations sent forth from this convention may meet the approval of sister organizations. The questions before us are:

QUES. 1. Do you approve of enlarging tank valve opening?

QUES. 2. Do you approve of stationary strainers placed around valve in tank?

QUES. 3. What size hole?

QUES. 4. Do you approve of increasing size of hole in present strainer?

QUES. 5. Do you approve of present make of strainers?

QUES. 6. Would you approve of lengthening present strainer?

QUES. 7. Would you approve of enlarging goose neck, hose bag and suction pipe beyond present size to meet demands of high (200 lbs.) pressure engines No. 10 injectors?

QUES. 8. Give your opinion as to lowering (lifting) injectors below water level in tank governing the overflow by use of plug cock in feed pipe.

In answer to question No. 1, your committee recommends that tank valves, goose necks, and all channels leading to suction end of injector, be made one size larger than called for by the injector connection, to insure sufficiency of supply at all times, reduce friction, and make allowance for occasional obstruction of these channels by dirt, scale, leaves, etc.

Our own personal experience has proved this to be an advantage, for aside from the opening being too small, the fact of lost motion in connecting rods caused by constant wear will eventually shut the necessary supply off. This we have found to be the case where plug valves are used.

In answer to questions Nos. 2, 3, 4, 5 and 6 we would say that we also endorse stationary strainers being placed around valve in tank, from the fact that more area can be obtained; the strainer should be accessible to the engineer, or shop force, by means of trap for the purpose of cleaning out any accumulations. The size of hole in same to be not more than one-eighth (1/8) inch. This would do away with the present conical-made strainer, which is an abominable nuisance. Its shape and location are altogether wrong, and it is fit only for the purpose of catching and retaining anything that may get into the pipe in the form of obstruction, and having insufficient area it then forms itself into what it really is, an obstructor. It is well known to all who have had the experience that two leaves are enough to shut off the supply, and knowing this, we suggest that the present strainer be abolished forever.

Ques. 7. We strongly advise the enlarging of goose neck, hose bag and suction pipes generally; not particularly for No. 10 size injector; but all. We recommend that the Association take up and try to induce the Mechanical Departments to demand larger connections, on the plea that experience shows that all injectors are benefited by larger suction pipes and accessories. The simplest way would be to establish standard sizes of suction pipes; say two inch inside diameter of pipe for Nos. 5, 6 and 7; two and one-half inch for Nos. 8, 9 and 10, three inches for larger than No. 10. Again the pipe should have as few joints as possible from the fact that the more joints the more liability of leaks, and the admission of air from such leak will destroy the necessary vacuum.

Another reason for increasing the size of pipe, etc., is due to the fact that when the "Gifford" injector was introduced in 1860 the size of pipe was fixed, and although the severity of the requirements has increased and the capacities have been enlarged nearly seventy-five per cent, at high steam pressures, yet the pipe diameters have remained the same; based upon these facts we make our recommendations.

Ques. 8. It is certainly desirable to place the injector as low as possible and to reduce the lift, which causes msst of the trouble, as a result of the fact that repairs to leaky steam valves and boiler checks, resulting in the heating of the suction pipes, are not always made in time, or cannot be made in time. The practice of placing injectors on modern high pressure engines two and three feet above the tank should be discouraged, as a lift of from six to seven feet, when the water is low in the tank, is very near the limit at which injectors will work reliably at high pressure. This limit

should never be approached. On the contrary, sufficient margin should always be left for wear of nozzles, leaky valves, obstructions in the water supply, as these defects become more serious with higher steam pressures and longer lifts. The placing of the injector just above the water level in tank, would certainly be conducive to promptness and reliability of action; it would enable the injector to deliver its full listed capacity, render the priming and starting more positive, and increase in every way its efficiency and convenience of operation by the engineer.

Respectfully yours,

L. D. GILLETT,
S. L. KNEASS,
E. W. BROWN,
J. C. CURRIE,
C. H. HOGAN,
Committee.

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The President: Gentlemen you have heard Mr. Gillett's report, it is now open for discussion.

S. L. Kneass (Wm. Sellers & Co., Incorporated): This is a subject that should not be passed without receiving careful consideration; I agree with most of the recommendations of Mr. Gillett, but there are one or two paragraphs of the report which I think should be amended.

On page 167, third paragraph, the suggestion of placing the strainer in the tank is good, but I do think there should be some change in the sentence regulating the size of the strainer holes; the sentence is misleading, in fact I think it says exactly what it is not meant to say. I would suggest that the sentence read "not *more* than $\frac{1}{8}$ to $\frac{1}{4}$ inch." According to my opinion the holes should be smaller, in fact not larger than $\frac{1}{8}$ of an inch. The object of the strainer is to keep not only the large particles of coal and dirt out of the suction pipe, but also small particles that are scooped up from the track tank. The usual opinion that the diameter of these holes is fixed by the smallest orifice of the tubes of the injector is radically wrong.

On the Pennsylvania Line I recently noticed a new pattern of strainer which was set in a cast iron pocket under the tender frame; it had a cylindrical strainer plate about $4\frac{1}{2}$ inches in diameter and

5 feet 6 inches long, punched with 3-32 inch holes; this, I think, is in the right direction for the reasons given.

The other point which I would like to amend is on page 168, relative to the position of injectors on the engine. I agree with the suggestion that the size of the pipes should be enlarged, and that the injectors should be set so that the lift is as short as possible. Manufacturers do all they can to produce injectors to give the best results, but the real remedy lies in the hands of the railroads; it is only necessary to specify what is wished and the requirements will be filled. Mr. Gillett advises the placing of the injector on a line with, or partly *below*, the level of the water in the tank to obviate the present trouble; I would like to amend this by recommending the placing of the injector just *above* the top water level of the tank. The Chairman of this Committee has gone over his argument for the position of the injector very clearly, but I would like to add that any duty required of the engineer, such as closing the tank valve every time the injector is shut off, simply takes that much of his time and attention from his other duties. If an injector is placed below the level of the water, it is necessary to look after the tank valves and this may be forgotten, inviting the further danger of a scarcity of water. Therefore I think his recommendation most unwise, especially as it places an unnecessary duty upon engineers, when the operation of the high speed locomotive of the present day makes so many demands on their attention. I would move an amendment to this report, "that the proper position of the injector is just above the top level of the water in the tank." Suggestions may also be made to the officers of railroads and also to locomotive builders to put on larger pipes and strainers, and to reduce the height of the lift. Builders are not unwilling to use larger pipes, but they are often instructed to put on sizes even smaller than the injector nipples. It is not a question of injector manufacturers being unwilling to meet the demands of the railroads, but is a question of possibility; when a railroad company or locomotive builder demands that an injector deliver its full capacity at high steam pressure, he asks an impossibility, unless the area of the suction pipe is ample and the height of lift is moderate. I therefore agree with the recommendations both as to height of lift and enlarging

the size of pipe connections. As is well known, the water supply is forced up in the injector by the pressure of the air on the surface of the water in the tank, and this pressure depends upon the vacuum in the injector or pump; the lifting power is almost constant at low steam pressures, but is somewhat reduced as the pressure is increased; it is not in the direction of stronger lifting power that the injector can be much improved. At high steam pressures the conditions are much more severe than at the lower pressures, as the vacuum in the combining tube is reduced; therefore it is much more difficult to obtain the full capacity of the injector with a small suction pipe at 225 pounds than at 150 pounds steam, and with a high lift than when the lift is short. The actual pressure which forces the water into the injector is very small, and any additional work required at high lift or friction of pipes, reduces the efficiency very seriously.

J. E. Minor (Nathan Mfg. Co.): I fully agree with Mr. Kneass; in fact I have to push on those lines, but it is surely a fact that the tank valve question is one of the most serious things; the locating of an injector below the water line is just as he says, and high pressure injectors of today to get feed water and good results must have the water and you cannot get water with your present tank valves. I cannot say anything further on this question, it has been fully covered in that paper and Mr. Kneass's remarks.

J. C. Currie (Nathan Mfg. Co.): I just want to add a few words; the object of this paper is to try, if possible, to induce the mechanical department of railroads and locomotive builders to give the present injector a greater volume or supply of water; when we stop to consider that in many instances the number ten injector of today is supplied by the same area of suction pipe, goose neck, tank valve opening and hose that the the No. 8 injector had, while the locomotive of today with just such connections is carrying 200 pounds and in one case I know of 225 pounds, you will see instantly that the injector should have more water. The question of the conical strainer is a good one and I am thoroughly in accord with all the committee has said in regard to it; it should be done away with forever. I have heard the argument that by making a longer strainer and a given number of holes in it count-

ing up the holes in the aggregate, that you have a greater area than you have in the old suction pipe; but that is a mistake because it seems to make that other part of blank copper between the holes decrease the area of your suction pipe; it certainly does not do any good.

Now in regard to lowering the injector, it has been found practicable on many systems of railroads to get the injector just as far down to the level of the water in the tank as possible; with a very high steam pressure, carrying long piping and small area as Mr. Kneass has stated, the injector has a great deal of work to perform and considerable of hard lifting; if an injector was brought down to the level of the tank, or as your Committee has stated a little below it, the life of the injector would be increased, it would be more capable, its action more prompt, it would be freer from scale on account of impurities in the water for steam making purposes. The higher the injector is placed the sooner it fills up and the lowering of the injector will do away with all these conditions which we meet every day, and while in the opinion of Mr. Kneass that it is not well to put it below the water line there are some parts of this country where the water is so bad they have to put the injector below the water.

The subject has been pretty thoroughly covered and I cannot say much more about it. The greatest and most important part of the paper, of course, is enlargement of the water pipe between the tank opening and the injector, and that should be done. It should receive prompt attention and due consideration at the hands of our mechanical concerns and locomotive builders; there is no merit whatever in a two inch pipe. I agree in large injectors, there is a possibility if the 2 inch pipe is kept absolutely clear of all obstructions, the washers coupling the hose of the goose necks is the exact size, we have not opening sufficient in that frequently cleaning your injector possibly may work as well with the 2 inch; when the weather is cold, condensing steam more rapidly than in the summer time when the weather reaches a temperature of from 75 to 84 degrees. I have known the water to be 84 degrees taken from a track tank where lying in the sun all day.

The President: In order to get through with the business today it will be necessary to have an afternoon session.

S. L. Kneass: Will it not be possible to close up this paper now, it will probably be possible to finish it this morning; we are all absolutely of one mind in regard to the subject and I would ask for an amendment to the report in regard to the position of the injector in regard to the water in the tank; I thoroughly agree with all the recommends.

The President: If the members so wish we will continue the discussion of this paper before adjournment.

Mr. Minor: I do not see what more there is to discuss, I think the paper covers the subject thoroughly; but if the other gentlemen would like to continue it I am willing; the recommend of the water lever might be changed by taking a vote on it.

Frank P. Smith (Hancock Inspirator Co.): I can only give you the practical side of four years observation in special lines of this kind in addition to my number of years of locomotive running. The injector question by the mechanical man has received less attention than any part of the locomotive. The last three years my only source of annoyance has been to get a sufficient amount of water and I am going to make a strong assertion, without fear of contradiction: not a railroad in this country that is carrying high pressure but are having trouble with their injectors regardless of the make, for the reason that they are not giving them an ample supply of either steam or water; you mention the fact to them and they will say, "That is our standard, we have always used that, the other fellow is not complaining, what is the matter with you?" Now that is what you hear throughout the country, the very idea of fitting a No. 10 injector on an engine carrying 200 pounds of steam with the same water passages that you do for a No. 7 injector is ridiculous, absolutely out of the question. The No. 7 with 2½ hose never got all it wanted even at low pressure, and by making the water passages large and liberal you increase the water and power of your injector because you lessen its labors. And another thing that the injector people have run up against very unexpectedly in the high pressure proposition—when you go up against high pressure and high altitude you go up against a stone fence that you were not looking for; no difficulty in high altitude until you want high pressure, then you go up against something hard; now it is a positive fact that the

capacity of the injectors above sea level and high altitude, say at 6,000 feet decreases 1,000 gallons, I know that from positive experience, the injector that has not at sea level a five foot lift, has got at an altitude of 5,500 feet, a lift of 13½ feet which decreases its capacity just that much. I have never found any difficulty yet when taking it up with the proper authorities, going into details and explaining why more water was required on their high pressure engines, I have never yet been turned down; of course it takes some little time and talk, but it can be done. I do not know but very few men in this country who make any stand and object to increasing the delivery, even though it varies from their standard; they all know when they get too large engines they have to increase their power; there is no reason why they should stick to the small water passages, and it is certainly well known to all injector men that the greater the demand on the injector the greater amount of water it takes to condense the steam, consequently they know more about it. Another condition that is lost sight of is increasing our check valve lift in order to get rid of the water.

The conical strainer that is spoken of, no matter if you have a strainer one foot long you cannot get any more water through it. Another thing the injector people are doing; the railroad companies have always said they must have so and so, but they have not made any provisions to give the other fellow what they wanted; the injector people have changed now to 2½ suction and say, you come to me, 2½ suction pipes calls for 3 inch hose, and if you want those boilers fed you will have to do as we want you to. The only way we can get this thing done is to lay it before the people in the proper way, and I have not found anyone yet who has objected to giving us the required amount of water.

C. B. Conger: The trouble with some of the injectors is that the water cannot get to them, neither can the water get away from them. I am sorry for the injector men when I look at the openings that fasten the 2½ inch hose on and find out that the hole in the casting is not 2 inches. You speak of the pipe that it does not handle the right amount of water, a good casting with a hole to suit the injector can easily be put on a tender with a 200 pound engine, the pipe the right thickness for strength; I think we can just as well change the other distance and allow them to have

plenty of room to have water go through. On the high pressure engines the jet does not produce the same vacuum as with low pressure ones, but in my travels around the country I see a good many injectors from the size of the tank pipes and connections and I am certain the water passages are only about one-half the proper area, some of them $1\frac{1}{2}$ inches to $1\frac{3}{4}$ inches for a No. 9 injector and with high steam pressure, and it takes power to lift water up four to six feet higher than is needed; when the water gets down to a certain point in the tank in high pressure engines the injector undertakes to lift the proper amount but cannot, no matter what the size of the openings are, if they set the injector too high with the high pressure and especially with the small connections, the injector fails to do its whole duty.

C. H. Hogan: I agree with Mr. Conger all except his sympathy for the injector man, I think it is the engineer and the traveling engineer who deserve the sympathy, who have to get along with the small openings, and I am highly in favor of increasing the openings from the tank valve to the injector and, as Mr. Smith said, we do not give lift enough to our check valves. This matter is not given enough attention; I have found where injectors are giving trouble and failed to work satisfactorily, in tracing out the trouble found the check had about $\frac{1}{8}$ inch lift at the boiler; those things lend a helping hand toward an engine failure. Today when we are drawing heavy fast passenger trains or heavy freight trains, engines loaded to more than their capacity, we have to have an injector that will put in all the water we need; No. 10 injector of any make will do it if provided with the connections as it should be. We are running today on many important roads I know of with the same old connections, that is the openings, water valves, strainer and tank valve they used on No. 8 injectors and now using them for the No. 10; we all know that if the opening is sufficient for the No. 10, the No. 8 was receiving an overabundance of water; it is just as Mr. Conger said in regard to the capacity, they do not make any difference in the connections, they will close up the openings from 2 to $1\frac{1}{2}$ inches as I have found myself, and the strainer in the hose is a nuisance and we should take great care that we have a good strainer in the hose, and it should be so arranged that it could be cleaned more readily than the

apparatus we have now, and it is a matter that should be given considerable attention here and we should recommend, if possible, the changes to be considered but at the same time not lose sight of the fact that we have to have a proper strainer in the well at the bottom of the tank to keep the dirt from the injector and the small hole even of the size the committee has recommended is too much. I think myself even $\frac{1}{8}$ inch is almost too large.

Mr. Minor: I believe a strainer in the well will stop up the injector just as bad as that you have now, and any device that is put in in that shape; there are strainers in the wells on the Pennsylvania railroad and other roads, there are some who have put in a larger tank valve, following out this general idea of tank valves, but a strainer in the well will fill up badly, it is easy to get at but it will stop up and injure the injector just the same. The new tank valve on the Pennsylvania is a key valve, one of the most easily applied things in the world and the strainer around it.

William Owen: As the time is short I will merely say, large piping should be put on; that makes quite a difference; a great many roads will put in large piping but they will put in soft iron or gas pipe which increases the water friction to quite an extent; I guess everything has been covered very fully and the old style strainer cannot be condemned too strongly.

Chas. H. Hogan: I did not mean that the strainer should be placed in the well but beneath the well.

L. D. Gillett: I may not agree with Mr. Kneass as to the location, I will not be alone, that is a foregone oonclusion, and I may say for your benefit, that we passed over a series of experiments, in the company's work. We found that with a No. 10 injector the opening of the tank was 1½ inches; we found also that with a B connection that we use, it was 1½ inches, we had trouble, engine failures every day. In the middle of our division we had to exchange injectors, we repaired injector, nothing wrong with it whatever, yet we had the same difficulty, bad workmanship in the shop, in the hose bag reduced your water capacity; we went to work on the tank valve and we increased that from 1½ inches to 2 inches we took up all that lost motion which will eventually return; no question about that supplying water if we increase it to 2 inches, we decreased the engine failures a good 65

per cent.; there was a weakness in the supply; then we did the next best thing without interfering with steam directly, we took the wire out of all hose bags and we let it be open to see effect, but is not safe to do it. Then we got new hose bags with wire back, then we had no trouble, and our injectors are working perfectly good. Yet like Mr. Smith has said to you, the temperature has a great deal to do with it, where the temperature is high, up to 70 and 80 degrees and it gets there even when it is not summer time, then we have the difficulty; and it is the connections that we, your Committee, strongly recommend made larger. Now as to question of capacity of the tender tank, that is a question which all, I think, will agree on and it only remains for Mr. Kneass to agree with us on the water line. You will remember when the injectors were set on the top of the boiler; we have come down, we have brought the injector down in some instances a difference of three feet, now it can stand another 14 inches and still not be too low in some cases, and if we have found improvements in lowering the injector as far as we have, then we will find a greater improvement and increased power by decreasing the lift, and we will get better results. It is in your hands, gentlemen, after satisfying Mr. Kneass on placing the matter on a water line; as near approach as possible to the water line and not go below, and I am satisfied that we have passed through what will be a great big improvement to all concerned and I would like to have it understood by the Master Mechanics that we took some action, and have it go out as the sense of this meeting to the Master Mechanic meeting. As the gentlemen said, from the influence they bring to bear it is possible for them to do as much in this line or more. If we follow this line and the points mentioned by the various interesting speakers we will have done a duty and conferred a benefit on the country at large.

D. Meadows: I would like to move that the recommendations of this Committee be accepted and discussion closed.

S. L. Kneass: I will present my motion now. I move that on page 167, line 19, the words "Not less than one-fourth" be made to read "Not more than one-eighth."

Frank P. Smith: I section that motion.

Carried.

S. L. Kneass: I move that this report be amended on page 168, line 10, by crossing out the words "on a line or partially below" and insert "just above" and eliminate the sentence "it would necessitate the closing, etc."

Mr. Minor: I second that.

Carried.

D. Meadows: I move that the report as it stands amended be adopted and the discussion closed.

Mr. Minor: Seconded.

Carried.

Chas. Hogan: Before you close this subject I want to say a word; I must confess I am not acquainted as regards the disposition of the proceedings and particular findings of this Committee, how they reach the individual railroad Superintendent, Master Mechanics, etc., my motion is made to cover that; that the action of this Convention, on this one subject at least, be communicated to the Motive Power Department of the different railroads which are at least represented here.

S. L. Kneass: I second that motion.

Carried.

The President: It will be necessary to have an afternoon session as there are some business matters of great importance to be taken up.

Long: I move we adjourn until 2 o'clock.

Carried.

# Fifth Session.

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Friday Afternoon, September 14th, 1900.

President Stack called the meeting to order at 2:10 P. M.

The President: I have been requested by members who wish to leave at three o'clock to have the election of officers first. We will appoint Mr. Hogan, Mr. Wildin and Mr. O'Rourke as tellers.

J. C. Currie (Nathan Mfg. Co.): Who is the first officer to be elected?

The President: The president is the first.

J. C. Currie: I move the Secretary cast the ballot as the sense of this Convention that Charles H. Hogan be President for the ensuing year.

Carried.

Charles H. Hogan: Mr. President and Gentlemen: It is very evident that this thing was pre-arranged, and it is also evident that I was not in on the deal. I just took lunch with Mr. Currie, and the least he might have done was to have given me an opportunity to be prepared for this shock, you might call it. All I can say, gentlemen, in addition to thanking you for the high honor you have bestowed on me, is that I would like to have it understood that I consider it a great honor. This Association has arrived at a time when it has become useful to the railway corporations; we are now independent you might say, and it has been brought about through many capable men belonging to this Association. The founders of this Association were men of brains and they, from time to time, instilled in the rest of us good knowledge, and posted us on matters that enabled us to be of valuable assistance to the Master Mechanics and Superintendents of Motive Power throughout the country, and for that reason we have made ourselves indispensable and have brought great credit upon ourselves, and for that reason I may say that I feel proud of

being elected President of an Association with the standing that we now have, and I again thank you for the honor.

The President: The next nomination in order is for First Vice President.

G. W. Wildin: I move the Secretary cast the ballot in favor of Mr. W. G. Wallace for First Vice President for the ensuing year.

J. F. Walsh; I second that motion.

The President: Nominations are now in order for Second Vice President.

J. F. Walsh: I would move you that Mr. Hogan cast the vote of the convention in favor of D. Meadows for Second Vice President.

Carried.

The President: The next nomination is for Third Vice President.

Lewis Gleason: I move that Mr. Henry Beck of the Jersey Central Road be elected as Third Vice President.

J. F. Walsh: I second that motion.

Carried.

C. B. Conger: I move the Secretary cast the ballot for Mr. Beck for Third Vice President.

The President: The next in order is for Treasurer. Mr. C. A. Crane is the Treasurer at present.

C. B. Conger: Mr. President, we cannot do better than Mr. Crane; he has stuck right to us through a great many years of trouble. I move the Secretary cast a ballot for Charles A. Crane as Treasurer for the next year.

Carried.

The President: The next in order is Secretary.

Mr. Long: Mr. President, I move that Mr. Conger cast a ballot for W. O. Thompson as Secretary.

Frank P. Smith: Seconded.

Carried.

The President: One member of the Executive Committee is to be elected; Mr. Conger's time has expired as one of the Executive Committee; nominations are in order.

Mr. Long: I make a motion that Mr. Thompson cast the ballot for Mr. Conger for member of the Executive Committee.

Mr. Gillett: Second.

The President: Gentlemen, the next thing in order is report of committees.

G. W. Wildin: Mr. President, I hold in my hand the ballot cast by the Secretary for Charles H. Hogan as President for the ensuing year. The ballot has been cast for W. G. Wallace as First Vice President. The ballot of the Association has been cast for D. Meadows as Second Vice President. The ballot has been cast by the Secretary for Charles A. Crane as Treasurer. The ballot has been cast for W. O. Thompson as Secretary. A ballot was cast for C. B. Conger as member of the Executive Committee for the ensuing year. I hold in my hand the ballot cast by the Secretary of the Association in favor of H. J. Beck as Third Vice President for the ensuing year.

The President: The next in order is the report of the Committee upon the Subjects for discussion for the next Convention. We will have Mr. Thompson read them.

W. O. Thompson then read the report as follows:

1. What benefits have been derived from the use of the Indicator by the Traveling Engineers?

G. W. Wildin, Chairman, C. B. Conger, A. S. Erskine, J. H. Maysilles, and T. E. Lewis.

2. Methods of firing locomotives to obtain best results, all conditions to be taken into consideration.

E. R. Webb, Chairman, Fred McArdle, E. F. Ingles, Clinton Decker, and E. E. Dellinger.

3. Locomotive lights, their care and operation.

W. E. Widgeon, Chairman, P. A. Eich, T. J. Bullock, P. J. Hickey, and M. A. Ross.

4. The best method of taking care of and handling the compound locomotives.

P. H. Stack, Chairman, R. Atkinson, A. E. Manchester, W. C. Hayes, and J. L. Pugh.

5. Is it a good practice to use grease to lubricate locomotive crank pins?

W. G. Wallace, Chairman, N. M. Maine, L. B. Hart, James Grey, and W. C. Dallas.

6. The proper and improper handling of the brake by the engineer at the brake valve.

H. C. Ettinger, Chairman, Robert Burgess, W. B. Galivan, C. P. Cass, and William Owens.

On change of Constitution and By-Laws.

J. C. McCullough, Chairman, N. Long, Geo. O. Taylorson, John Donovan, and I. H. Brown.

Subjects for discussion in 1902.

F. O. Miller, Chairman, W. H. Greene, J. W. Hall, Geo. H. Horton, and W. O. Taylor.

Committee of arrangements for the next annual meeting.

H. J. Beck, Chairman, Geo. W. Keys, J. C. Currie, Chas. Conlisk, Harry Vissering, W. J. McCarroll, and W. P. Steele.

The President: You have heard the report of the Committee on Subjects; what is your pleasure?

J. F. Walsh: I move that it be adopted as read.

Mr. Long: I second that motion.

Carried.

The President: We have another report here from the Committee on Constitution and By-Laws which the Secretary will read.

Secretary reads report.

Mr. President and Members,
Traveling Engineers' Association:
Your Committee on By-Laws would recommend that Article 3 Section 1 be changed to read, "recommended by three members" instead of "one".

Committee:
D. N. Winegar.
Wm. Owens.
E. R. Webb.
C. F. Schraag.
C. F. Keith.

The President:—You have heard the report of the change in Constitution and By-Laws as recommended by the Committee. What is your pleasure in regard to it?

C. H. Hogan: I move the report be received and accepted as read.

The President: You have heard the motion made by Mr. Hogan, seconded by Mr. Meadows. All those in favor will give the usual sign.

Carried.

J. Walsh: I am sorry to say to you that I did not know that subject was up.

G. W. Wildin: The Constitution says it requires a two-thirds vote of the members psesent and there were only about one-fifteenth who voted.

The President: We will take another vote.

Lost.

The President: Any other business, Mr. Secretary?

Secretary: The report of the committee on memorial of George A. Hill.

Mr. Thompson read the report as follows:

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## IN MEMORIAM.

### GEORGE ALBERT HILL.

Since our last annual meeting, the Traveling Engineers' Association has lost a worthy and respected member by the death of Mr. George A. Hill, which sad event took place at his beautiful home in the village of Matamoras, Pa., July 17th, 1900.

George Albert Hill was born at Charleston, N. H., in 1853 and was the son of E. O. and Ruth S. Hill. When he was one year old his parents moved to Norwalk, Ohio. He served his apprenticeship as a machinist in the railway shops at Norwalk, after which he resided for a short time at Kent, O., and from there went to Meadville, Pa., and entered the office of Mr. John Van Vechten, the then Master Mechanic of the Erie Railway shops at that place, as draughtsman.

In the early eighties he was offered the position of Master Mechanic of the Erie Railway shops at Greenwood Lake, N. J., which position he accepted and retained for two years, resigning to accept the position of Master Mechanic of the Chicago & Erie Railway at Huntington, Ind. In 1885 Mr. Hill accepted a position with the Galena Oil Co., of Franklin Pa., as traveling representative; with this company he remained until his death.

In the various positions of trust and responsibility which Mr. Hill filled during his life he was ever found capable and competent and faithful to the interests of his employers. He was a man of sound judgment and good sense. All his actions were squared to a high standard of duty and principle; he was endowed with most excellent qualities, and was held in highest esteem in religious, business and social circles. One of his most marked characteristics was his warm friendship for those who had gained his confidence; "Once a friend, always a friend" was one of his mottoes.

His home life was ideal. He was united in marriage October 28th, 1874, to Miss Belle Armstrong of Norwalk, O., by whom he is survived. Their family consisted of three daughters, two of whom are married, all residing at Matamoras, Pa., where Mr. Hill made his home for many years.

His untimely death is deeply regretted by his fellow-townsmen, as it is by all who had the pleasure of his acquaintance. He was an unselfish man; he performed a great amount of charitable and philanthropic work of which the general public had no knowledge. He assisted the poor to a great extent and those in need always found a generous sympathizer and helper in Mr. Hill. Of him it can be said, "None named him but to praise." But alas, in the prime of his useful life he is removed from our midst. While we mourn his departure we bow in submission to the will of our Heavenly Father and humbly say "Thy will be done."

The following preamble and resolutions were unanimously adopted by the Traveling Engineers' Association in convention assembled:

WHEREAS, this Association has heard with much sorrow of the death of our esteemed member, Mr. George Albert Hill, therefore resolved, that in the death of Mr. Hill his family has lost a loving husband and kind father, the Galena Oil Co. an honored and trusted employe and this Association a most worthy member.

*Resolved*, that we tender to the family of our deceased member our sincere sympathy in the great loss they have sustained. Be it further resolved that a copy of this preamble and resolution be suitably engrossed and duly signed by the President and Secretary of our Association, and the same presented to the family of our late member as a token of respect and esteem to his memory.

LEWIS GLEASON.
GEO. W. O'NEAL.

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The President: A motion will be in order to accept the report as read by Mr. Thompson.

G. W. Wildin: I move that it be the unanimous sense of this convention that this report be adopted and that the resolutions be signed and delivered to the proper parties.

J. R. Belton: I second that motion.

Carried.

The President: I believe the ladies were to come in and help settle the question of the next meeting. Will one of you gentlemen kindly notify them to come in?

While we are waiting for the ladies we would like to hear from Mr. W. G. Wallace, the First Vice-President.

W. G. Wallace: Mr. President and gentlemen: I had to come up here with my friend Mr. Hogan, and get on his side of the fence. I am not a speech maker and do not know what to say on this occasion. I am a little surprised but I hope the duties will be light, which I think they will be; however, I would consider it an honor and pleasure to serve your best interests. I have listened to many able speakers during this convention and I think we may all go home feeling glad that we came here. We come here and a great many able and interesting speakers pat us on the back, as it were, and tell us that the great and excellent results that are brought about on railroads are largely due to the efforts of the Traveling Engineer; they try to make us feel good. Now my experience has been that the Traveling Engineer is only one cog in the wheel, and when we go home to our respective duties we come in contact with the men who are handling the locomotives and are making the records for our Master Mechanics. The best record that we can make for a Master Mechanic or any superior officer is the showing that we can put up on the monthly report or the blue print. It is rather late in the day to economize when he has asked for reasons. What we want to do is get out in the field and do our work; now then what is our work. I worked for a man on one occasion; I told him I was not told to do a certain thing. He said to me, "I can get a machine to do what it is told, I consider you are not a machine. I want you to use your judgment." I will say that he was a progressive man. Now a great many of us are out working with the enginemen to improve the service; some of you report to the Superintendent of Motive Power, others to the General Superintendent, but I will ask you, are they in a position to give you instructions which you require? There are no instructions that can be laid down for your guidance; you are in the place to make the best of it; a great many of you cannot change conditions, you simply have to get along the best you can with your work and try and get the boys interested in your work and their work and show by your efforts in that line that you are improving the service. It is hard work; takes you out of the office, keeps you off of the passenger trains where you have your best men; of course it is all right to ride on the passenger train at times. We may feel complimented on the references that have

been made as to what we are doing; we want to continue on that line and improve ourselves, check ourselves up. It is safe to say that nine out of ten engineers has his improvement in his own hands; he can be lazy and sit around the office a great deal and be busy doing nothing, or he can be out where he is not seen; I hope when we all return to our respective divisions that we will be able to improve the knowledge we have gained at the convention, and convey it to those who are working with us to improve the service, and I am sure we will get results that will be gratifying to you all.

I thank you for electing me as Vice-President of your Association.

The President: Nominations are in order for the next place of meeting. We will appoint Mr. Owens, Wm. Walsh and Mr. McCullum as tellers.

The following cities were placed in nomination for the next annual meeting: Denver, Chicago, Boston, Rochester, New Haven, Philadelphia.

Mr. Hurley: I move the nominations be closed.

J. F. Gettrust: I second the motion.

Carried.

The President: We will now vote for the following cities for our next meeting: Denver, Philadelphia, Boston, Rochester, Chicago and New Haven.

While we are waiting for the vote we will read the report of the Committee on Thanks. Mr. Thompson, will you kindly read the report?

W. O. Thompson reads the report.

The Traveling Engineers' Association desires to return their sincere thanks to the following corporations and individuals for courtesies extended during their 8th Annual Convention, held in the city of Cleveland, O., Sept. 11th to 14th inclusive, 1900:

To his Honor, Mayor Farley, for welcoming us through his representative, Mr. Beacom, Asst. Corporation Counsel; to Rev. Dr. Ward Beecher Picard for opening our convention with prayer; to Assistant Manager P. P. Wright of the L. S. & M. S. R'y. for his very able address at the opening of our convention; to Gen'l Manager McCormick of the Big Consolidated Street R'y. Co. for his many courtesies to the members of the Association and their ladies, and by request of our ladies we wish to especially thank him for his personal supervision and the many courtesies extended by him to them while inspecting the power house, visit-

ing the Garfield Monument and Manhattan Beach; to the management of the Colonial Hotel for their many special kindnesses and acts of attention during our stay; to Grand Chief P. M. Arthur of the B. of L. E. for his timely and eloquent address; to the officers and members of No. 1 Fire Co., C. F. D., for the exemplification of their work, and other courtesies extended; to Mr. H. C. Ware for his thoughtfulness and kindness in presenting to our ladies souvenirs of their visit to the beautiful Lake View Cemetery and Garfield Monument; to the various Railway Supply Companies and their representatives who were tireless in making our convention pleasant and instructive; to Messrs. C. H. Stalker, P. J. Hickey, D. N. Winegar, W. C. Bryant, C. C. Houghton and W. O. Thompson, members of the Committee of Arrangement, who were the personification of hospitality, kindliness and thoughtfulness in making our stay in Cleveland one to be remembered; to Mr. J. A. McKensie, Sup't. of Motive Power of the Nickle Plate R'y., for his address and attendance at our meetings; to the Pullman Palace Car Co. for courtesies extended and transportation furnished; to the various railways and the International Correspondence School for sending their air brake instruction cars; to the various railway companies for courtesies extended members of this Association; to the citizens of Cleveland in general and to those with whom we had business dealings in particular, all of whom we found unsparing in their efforts to make our stay pleasant.

Committee: Lewis Gleason. J. F. Walsh. J. A. Baker.

The President: You have heard the report of the Committee on Thanks; what is your pleasure?

Eugene McAuliffe: I move the report be accepted as read.

Seconded by Minor.

Carried.

Lewis Gleason: In addition to the thanks already extended to Mr. McCormick the Manager of the City Railway Line, I think it would be appropriate from what I have heard of the gentleman's kindness to the members of this convention, and the ladies in particular, that a special letter be written to Mr. McCormick and signed by the President and Secretary of this Association, giving him still further thanks in addition to what he has already received.

C. H. Stalker: I second the motion.

Carried.

Secretary Thompson: I would like to announce that there

are quite a number of Committee Reports left, and perhaps a good many members here would like to take some home with them.

The President: While we are waiting for the tellers we would like to have a little talk from Mr. Currie.

J. C. Currie: You certainly do me a very great honor, and one that was entirely unexpected on my part. I did not expect to be called upon to say anything at this time, but I will say that I feel proud that I am a member of this Association and I am also proud to know that the Association is growing to the extent that it is. It has been said today that this Association is helpful to the Superintendent of Motive Power and Master Mechanic on the different railroads of this country, and they cannot truthfully deny that it must be helpful; it could not be otherwise than helpful. The subjects that are discussed are of vital importance to the improvement of the railway service, and especially the mechanical service of this country. The interest you have taken in the papers discussed has been manifested by your opinions at the meetings, and I am proud to see this room so crowded when the discussion was on the subject of smokeless firing, showing very conclusively and clearly that every one of you are interested in this important subject. If you continue on in the lines you have laid down and are following at this time,—while you have made yourselves valuable to those whom you serve,—you can still make yourselves more valuable by increasing the interest which you take in this Association and its proceedings. As I said before, I am pleased I am a member of this Association and also pleased to look around me and realize that 95 per cent. of you who belong to this Association have graduated from the footboard of an engine; it is something to be proud of, when we know that men in these deliberations for the improvement of the locomotive service, have themselves graduated from that very footboard. Go on in your good work; be earnest in your endeavors; continue on as you are doing, and I have not the slightest doubt but that success will be yours. I thank you, Mr. President and gentlemen, for the honor you have done me, I thank you very sincerely indeed, and I trust if I live I may be able to meet you in your future conventions and take an active part in your proceedings.

The President: Mr. Walsh will read the result of the vote.

J. Walsh: The vote was as follows: Denver 5, Chicago 9, Boston 4, Rochester 3, New Haven 9, Philadelphia 23.

The President: According to the Constitution and By-Laws Philadelphia, receiving the highest number of votes, is the next place of our meeting.

J. S. Bauder: I notice Mr. McCormick is in the room; maybe he would make a few remarks.

The President: Mr. McCormick, we would be pleased to have a few remarks from you.

Mr. McCormick: I believe the gentleman said Mr. McCormick would like to make a few remarks; but as there has been a vote cast thanking me for the small way in which I have been able to contribute to the pleasure of the members of the Traveling Engineers' Association, and particularly the ladies, I only have been too glad to do it, and I assure you the pleasure has been mine in any way that I could contribute to their pleasures or their friends', and I wish to say any time the members are in Cleveland I would be glad to have them look me up and call on me.

The President: Mr. Walsh, we would like to hear from you now.

J. F. Walsh: It seems to me you have heard enough from me, but Mr. President and gentlemen as long as you have called on me I will say to you that I consider it quite an honor to have been called on, and I do not know what more I can say than to repeat all that my friend Mr. Currie has said. I am afraid that one great trouble with us as Traveling Engineers or as members of this Association is perhaps that we do not fully realize the importance of the position that we hold. From my point of view the position of Traveling Engineer on a railroad is one of the most important in connection with the mechanical department; as Traveling Engineer we have direct control of the men on the engines, for upon the work that those men do, railroad companies depend for their profits; one of the things that we hear complained of quite bitterly by locomotive engineers, is the tonnage proposition; they have not, by a long ways, disabused their minds of the old feeling of individual ownership of the engine; dating back a few years, each man had his own regularly assigned engine. The freight rates in those days were higher than now; close competition has made

it necessary for raiload companies to reduce their rates in order that they may make profit enough to pay the interest upon their stock and bonds and their other many expenses; they have got to get the most out of their power they have to move their business with, and I would suggest that it can be done, if the Traveling Engineer will get as close to the men as possible and get them to take the view that upon the profits a company gets from their work depends the means the company has for paying them their wages and the rate of wages they now pay them, and that the continuance of the rate of wages depends upon the prosperity; and as the company's profits depend upon the work, they have it in their own hands to make their pay higher or to bring about a reduction. Now in my travels about the country I frequently come across men who complain that their engines are over-loaded. Do you stall? No, but we have all we can drag, the last ton. Well now when you stop and reason with those men and explain that upon that very last ton or the very last car perhaps depends the profit and the only profit in that train, those men take an altogether different view of it; therefore I say, we ought to get as close as possible to them, reason with them; do not be imperative and say you must do so and so because it must be done, but explain why it should be done. If men are troubled with mechanical defects, as I heard remarked today, explain to those men that there is nothing to do but to find the cause that brought it about, and with them go to work and locate the cause; as soon as it is located, remedy it and take them into your confidence while you are doing so; by this means you get a much better man and much better results; therefore, gentlemen, I say to you that whatever we may know from our experience as Traveling Engineers, let us take our men into our confidence and give them the benefit of how we found it out; get them disposed to think, and you have accomplished a great deal, and get out with your men and impress upon them that upon their work depends the profits of the railroad companies.

Secretary Thompson: As you all know, one of our members, Mr. James McDonough, came here about the time of the bad storm in Galveston; the storm district took in their home and they could not hear a word from there and they left two children

at home; they left for home and you all know how they felt when they left. I received a message from them dated this morning and it says the children are safe. Applause.

J. C. Currie: I would move you that the Secretary of this Association be empowered to wire Mr. and Mrs. McDonough the congratulations of this Association on behalf of the safety of their children.

Mr. Walsh: I second that motion.

Carried.

The President: If there is no other business to come up a motion will be in order to adjourn.

Martin Monroe: I am going to be like the women and have the last word; I move we adjourn to meet in Philadelphia next year.

C. B. Conger: I second the motion.

Carried.

The President: Gentlemen, we will now adjourn to meet in Philadelphia the second Tuesday in September, 1901.

GEORGE ALBERT HILL.

## Committees for 1900-1901, and Subjects for Discussion at Next Annual Meeting, to be held at Philadelphia, Pa., Commencing Second Tuesday in September, 1901.

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1. What benefits have been derived from the use of the Indicator by the Traveling Engineers?

G. W. Wildin, Chairman, C. B. Conger, A. S. Erskine, J. H. Maysilles, and T. E. Lewis.

2. Methods of firing locomotives to obtain best results, all conditions to be taken into consideration.

E. R. Webb, Chairman, Fred McArdle, E. F. Ingles, Clinton Decker, and E. E. Dellinger.

3. Locomotive lights, their care and operation.

W. E. Widgeon, Chairman, P. A. Eich, T. J. Bullock, P. J. Hickey, and M. A. Ross.

4. The best method of taking care of and handling the compound locomotives.

P. H. Stack, Chairman, R. Atkinson, A. E. Manchester, W. C. Hayes, and J. L. Pugh.

5. Is it a good practice to use grease to lubricate locomotive crank pins?

W. G. Wallace, Chairman, N. M. Maine, L. B. Hart, James Grey, and W. C. Dallas.

6. The proper and improper handling of the brake by the engineer at the brake valve.

H. C. Ettinger, Chairman, Robert Burgess, W. B. Galivan, C. P. Cass, and William Owens.

On change of Constitution and By-Laws.

J. C. McCullough, Chairman, N. Long, Geo. O. Taylorson, John Donovan, and I. H. Brown.

Subjects for discussion in 1902.

F. O. Miller, Chairman, W. H. Greene, J. W. Hall, Geo. H. Horton, and W. O. Taylor.

Committee of arrangements for the next annual meeting.

H. J. Beck, Chairman, Geo. W. Keys, J. C. Currie, Chas. Conlisk, Harry Vissering, W. J. McCarroll, and W. P. Steele.

# CONSTITUTION.

ARTICLE 1.—The name of this Association shall be "The Traveling Engineers' Association."

ARTICLE 2.—The object of this Association shall be to "Improve the Locomotive Engine Service on American Railroads," through the advancement of knowledge concerning the duty of traveling engineers or road foremen, by discussion in common, the exchange of information on subjects interesting to its members, thereby making the work in all branches more systematic and efficient for its members, and profitable for railroads, and to provide an organization through which, by joint action, the best methods may be adopted.

ARTICLE 3.—*Section 1.* The following persons may become active members of the Association by being recommended by one member of good standing, and signing an application for membership, and agreement to conform to the requirements of the Constitution and By-Laws, or signing the Constitution and By-Laws.

*Section 2.* (*a*) Traveling engineers in active service, whether assigned to duty on the entire system of railroad or on a single division of any road; their assistants, when said assistants have charge of a division and are responsible for the condition of the engine and the discipline of engineers and firemen to the same extent the traveling engineer is; provided that said assistants are not engaged in one line of duty only, such as instructions in firing coal properly, or inspector of engines when in round houses.

(*b*) Those who have been traveling engineers, and have been promoted to other positions of railroad service.

(*c*) Experts in air-brake practice employed by the railroads or air-brake companies.

(*d*) General Foremen, when they have been promoted from the position of Locomotive Engineer.

(*e*) Round House Foremen, when they have been promoted from the position of Locomotive Engineer.

(*f*) Any active member of the Association who is promoted to Master Mechanic, Superintendent of Motive Power, Superintendent, or General Superintendent, may be made an Honorary member. The dues for such members shall be one dollar ($1.00) per year. The Honorary Membership list shall be limited to fifteen members.

(*g*) Those whose knowledge of locomotive running and management will be of service to the Association can be admitted as associate members at any meeting by a majority vote, provided no associate member shall have voice or vote upon the election of any officer in the Association.

The title Road Foreman of Engines is taken to mean the same as Traveling Engineer.

*Section 3.* All members, except as hereinafter provided, shall be subject to the payment of such annual dues as it may be necessary to assess for the purpose of defraying the expenses of the Association, provided that no assessment shall exceed $5 a year. Such dues shall be payable when the amount thereof shall be announced by the President at each annual meeting. Any member who shall be one year in arrears for dues, and neglecting to pay the same within three months after notification by the Secretary, will have his name taken from the roll. Members whose names have been dropped for non-payment of dues may be restored to membership by the unanimous consent of the executive committee, and on the payment of all back dues.

*Section 4.* Any member who, during the meetings of the Association, shall conduct himself in an unbecoming manner, may be expelled by a two-thirds vote of the members present at any regular meeting within one year from the date of the offense.

ARTICLE 4.—*Section 1.* The president will be chairman of the executive committee.

*Section 2.* The officers of the Association shall be a president, a first vice-president, a second vice-president, a third vice-president, a treasurer, a secretary, and three members of the Association, who shall be elected by ballot at the regular annual meeting, who shall, with the officers, constitute the executive committee.

ARTICLE 5.—The president, first vice-president, second vice-president, third vice-president, treasurer and secretary, shall hold office for one year, or until successors are chosen; the three members to serve on the executive committee will be first elected to serve for one, two and three years respectively; their successors shall be elected to serve for three years.

ARTICLE 6.—*Section 1.* The duties of the president, vice-presidents, treasurer and secretary, shall be such as usually pertain to their offices, or may be delegated to them by unanimous vote of the executive committee.

*Section 2.* In case of death or resignation of any officer except the president, the executive committee can have the power to elect his successor to serve the balance of the fiscal year.

*Section 3.* The treasurer shall give bond, the amount to be decided by and filed with the executive committee.

ARTICLE 7.—The executive committee shall exercise a general supervision over the interests and affairs of the Association, recommend the amount of the annual assessment, to call, to prepare for and conduct the general conventions, and to make all necessary purchases, expenditures and contracts required to conduct the current business of the Association, but shall have no power to make the Association liable for any debt to any amount beyond that which at the time of contracting the same shall be in the treasurer's hand in cash and not subject to prior liabilities. All expenditures for special purposes shall be made by appropriations acted upon by the Association at some regular meeting. Five members of the executive committee shall constitute a quorum for the transaction of business.

ARTICLE 8.—*Section 1.* At the first session of each annual meeting an auditing committee consisting of three members, not officers of the Association, shall be elected by ballot. It shall be their duty to examine at once the accounts and vouchers of the treasurer, and the books of the secretary, and certify whether they are correct or not. After the performance of this duty they shall be discharged by the acceptance of their report by the Association.

*Section 2.* At each annual meeting the president shall appoint a committee of five whose duty it shall be to report at the next annual meeting subjects for investigation and discussion, and if

the subjects are approved by the Association, the president shall appoint special committees to report on them. It shall be the duty of the committee to receive from members questions for discussion, which, if the committee determine are suitable, shall be reported to the Association at the same meeting.

ARTICLE 9.—This constitution can be amended at any regular meeting by a two-thirds vote of the members present.

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## BY-LAWS.

SECTION 1.—The regular meeting of the Association shall be held annually on the second Tuesday in September.

SECTION 2.—The regular hours of session shall be from nine (9) o'clock a. m. to two (2) o'clock p. m.

SECTION 3.—Places for holding the next annual meeting may be proposed at any regular meeting of the Association. Before the final adjournment the places proposed shall be voted for by the members; the place having the highest number of votes, shall be declared the place for holding the next regular convention.

SECTION 4.—At any regular meeting, fifteen or more members shall constitute a quorum.

SECTION 5.—Order of business: 1. Address of the President. 2. Reports of Secretary and Treasurer. 3. Election of Auditing Committee. 4. Unfinished Business. 5. New Business. 6. Reports of Committees. 7. Reading of Papers for Discussion of Questions Propounded by Members. 8. Election of Officers. 9. Adjournment.

SECTION 6.—Unless otherwise ordered, the discussion of questions proposed by members shall be the special order from 12 o'clock noon to 1 o'clock p. m. of each day of the annual meeting.

SECTION 7.—No patentees or their agents shall be admitted to the meetings of the Association for the purpose of advocating the claims of any patent or patentee, unless by unanimous consent.

## ACTIVE MEMBERS.

Anthony, W. J.............................................C. & N. W.
414 Wolcott St., Escanaba, Mich.

Ayers, Claude..............................................F. W. & D. C.
Clarendon, Texas.

Atkinson, R..............................................Canadian Pacific.
8 Park Logan, West, Montreal, Can.

Belton, J. R.............................................C. & O.
1414 Madison Ave., Covington, Ky.

Bauder, J. S.............................................L. S. & M. S.
P. O. Box 558, Collinwood, Ohio.

Burns, J. H.............................................B. C. R. & N.
1333 B Ave., Cedar Rapids, Ia.

Burke, M. W.............................................Wabash.
518 S. Williams St., Moberly, Mo.

Brown, I. H.............................................Westinghouse A. B. Co.
1621 Greenup St., Covington, Ky.

Bischoff, G. A.............................................Nathan Mfg. Co.
180 Old Colony Building, Chicago, Ill.

Barr, J. N.............................................B. & O.
Baltimore, Md.

Bickel, A. M.............................................L. S. & M. S.
206 St. Joe St., Elkhart, Ind.

Booker, W. E.............................................Silverton Ry.
Box 234, Silverton, Col.

Bryant, W. E.............................................Detroit Lubricator Co.
177 Avery Ave., Detroit, Mich.

Berndt, F. H.............................................care of Waters, Pierce Oil Co.
Mexico City, Mex.

Brantly, B. B.............................................Mexican National.
San Luis Potosi, Mex.

Breen, W. N.............................................A. T. & S. F.
502 Constitution St., Emporia, Kan.

Brown, E. W.............................................Erie.
432 Loder St., Waverly, N. Y.

Bodamer, E. A.............................................W. N. Y. & P.
343 Eagle St., Buffalo, N. Y.

Bruce, James.............................................Northern Pacific.
5515 Pine St., South Tacoma, Wash.

Bates, E. C. .......... Ewald Iron Co.
57 Broadway, N. Y.

Boughton, W .......... F. & P. M.
722 Carroll St., Saginaw, Mich.

Bair, D. H. .......... Southern Pacific.
2326 M St., Sacramento, Cal.

Burgess, Robt .......... Westinghouse A. B. Co.
Room 22, Chamber of Commerce, Richmond, Va.

Bullock, T. J .......... C. & O.
Huntington, W. Va.

Birney, Melville .......... Union Pacific.
Rawlins, Wyoming.

Beck, H. J .......... C. R. R. of N. J.
168 Whiton St., Jersey City, N. J.

Baldwin, A. C .......... Erie.
14 Gladstone Ave., Cleveland, Ohio.

Brees, D. H .......... Union Pacific.
512 5th St., Laramie, Wyoming.

Beardsley, A. L .......... A. T. & S. F.
Chanute, Kan.

Bronson, J. B .......... E. & W. V.
417 Elm St., Dunmore, Pa.

Best, Otto .......... N. C. & St. L.
Nashville, Tenn.

Benjamin, J. D .......... C. & N. W.
507 7th Ave., Clinton, Iowa.

Bowles, F. T .......... L. E. & W.
care of L. E. & W. Shops, Lima, Ohio.

Bevier, A. M .......... Montana Central.
P. O. Box 643, Great Falls, Montana.

Barry, J. C .......... Ohio River R. R.
42 8th St., Parkersburg, W. Va.

Baker, Joseph A .......... Ohio Central.
Ohio Central Ry. Depot, Columbus, Ohio.

Cunningham, H. B .......... W. & L. E.
22 Newton St., Norwalk, Ohio.

Cushing, G. W .......... Mec. Engr.
615 University Place, Chicago, Ill.

Conger, Wm .......... C. M. & St. P.
Marion, Ia.

Conger, C. B .......... Loco. Engineering.
1005 Manhattan Building, Chicago, Ill.

Curry, H. M .......... Northern Pacific.
927 Westminster St., St. Paul, Minn.

Coffin, J. S .......... Galena Oil Co.
Franklin, Pa.

Chapman, J. K....................................................Erie.
23 Union St., Hornellsville, N. Y.
Cass, C. P.........................................American Brake Co.
2d & Tyler Sts, St. Louis, Mo.
Coates, J. S.............................................Galena Oil Co.
6935 Kimbark Ave., Chicago, Ill.
Clewer, Harry.................................................C. & A.
Slater, Mo.
Crane, C. A............................................A. T. & S. F.
141 Peck St., Fort Madison, Ia.
Collins, A. B................................................C. B. & Q.
1017 Summer St., Burlington, Ia.
Case, W. N.......................................Michigan Central.
1223 East Main St., Jackson, Mich.
Currie, J. C.........................................Nathan Mfg. Co.
92-94 Liberty St., New York, N. Y.
Cummings, G. L..................H. & St. J. and K-C. St. J. and C-B.
912 South 14th St., St. Joseph, Mo.
Cook, K. R..................................Waters, Pierce Oil Co.
2d San Francisco 11, Mexico City, Mex.
Chamberlain, J. W.................................Boston & Albany.
17 Wrentham St., New Dorchester, Mass.
Cavey, W. E....................................................B. & O.
1332 South Charles St., Baltimore, Md.
Cotter, Chas.................................Duluth & Iron Range.
Two Harbors, Minn.
Caffery, Thos...............................................L. E. & W.
Tipton, Ind.
Casey, D. E.................................................D. L. & W.
546 Adams Ave., Scranton, Pa.
Cheney, M. P........................................Pere Marquette.
Ionia, Mich.
Collings, T. J.................................................N. & W.
Crewe, Va.
Carey, J. T....................................................N. & W.
P. O. Box 676, Bluefield, W. Va.
Conlisk, Chas......................................Wm. Sellers & Co.
1606 Mount Vernon St., Philadelphia, Pa.
Campbell, N. A...................................N. Y. Air Brake Co.
1403 Fisher Building, Chicago, Ill.
Davis, R. D.........................................Illinois Central.
3453 Cottage Grove Ave, Chicago, Ill.
Dallas, W. C..............................................Galena Oil Co.
Franklin, Pa.
Dyer, F. W................................................Galena Oil Co.
305 Lyndale Ave., North Minneapolis, Minn.

Davis, Chas........................................................Erie.
352 North Division St., Buffalo, N. Y.
Donovan John.............................................Central Vermont.
31 Congress St., St. Albans, Vt.
Detro, A. E................................................C. R. R. of N. J.
Maunch Chunk, Pa.
Daze, Wm................................................Santa Fe Pacific
Winslow, Arizona.
Dennison, James..................................................B. & O.
216 Lawrence St., Newark, Ohio.
Dean, M. C...............................................West Shore.
Pulver Ave., Ravina, N. Y.
Danforth, W. P..............................................M. K. & T.
601 Hull St., Denison, Texas.
Dailey, C. H.........................................Int. Cor. Schools.
Box 173, Sturgis, Mich.
Dickson, J. T.......................................Mexican Central.
227 Owens St., Denison, Texas.
Decker, Clinton ...................................................M. & O.
1934 Walnut St., Murphysboro, Ill.
Duffey; W. J.......................................................B. & O.
McMechen, W. Va.
Doucett, C. M.....................................................C. G. W.
640 10th St., Des Moines, Iowa.
Emerson, G. A.........................................Great Northern
Glasgow, Montana.
Eich, P. A.......................................................T. St. L. & W.
Frankfort, Ind.
Erskine, A. S.............................................................
1097 W. 19th St., Chicago, Ill.
Edwards, C. C.....................................................C. G. W.
476 Greenwood Ave., St. Paul, Minn.
Ettinger, H. C......................................................Wabash
care of Wabash Shops, Springfield, Ill.
Fraser, P...........................................................B. R. & P.
31 Jefferson St., Bradford, Pa.
Fenn, F. D.................................Crane Co., Air Brake Dept.
Chicago, Ill.
Fleming, D. A..................................................L. S. & M. S.
513 Marion St., Elkhart, Ind.
Frazer, H. C.................................Westinghouse A. B. Co.
114 Scott St., San Francisco, Cal.
Farmer, F. B.................................Westinghouse A. B. Co.
634 Endicott Building, St. Paul, Minn.
French, Frank..................................................F. W. & D. C.
Clarendon, Texas.

Foote L. E.............................................St. L. & S. F.
Newberg, Phelps Co., Mo.
Flynn, H. A.............................................Int. Cor. Schools.
304 Scott St., Wilkesbarre Pa.
Fairbrother, G. S.............................................N. & W.
Patterson Ave., Roanoke, Va.
Griffith, E. W.........................Schenectady Locomotive Works.
35 Barrett St., Schenectady, N. Y.
Gleason, Lewis.............................................Galena Oil Co.
Franklin, Pa.
Gibson, J. A.............................................C. C. C. & St. L.
Cor Delaware and South Sts., Indianapolis, Ind.
Gould, G. W.............................................M. St. P. & S. Ste. M.
1625 Stevens Avenue, Minneapolis, Minn.
Goble, R. S.............................................Southern Pacific.
144 South Alta St., Los Angeles, Cal.
Graff, J. C.............................................C. & N. W.
1124 W. 6th St., Winona, Minn.
Gesner, B. C.............................................Intercolonial.
Box 29, Moncton, New Brunswick.
Grey, James.............................................Santa Fe Pacific.
Box 84, Needles, Cal.
Galivan, W. B.............................................B. & O. Southwestern.
190 Scioto Ave., Chillicothe, O.
Gordon, Eugene.............................................Mexican Central.
care of Mexican Central R. R. Shops, Chihuahua, Chihuahua, Mex.
Grenne, W. H.............................................D. S. S. & A.
324 Washington St., Marquette, Mich.
Gillet, L. D.............................................N. & W.
345 Campbell Ave., Roanoke, Va.
Grieves, E. W.............................................Galena Oil Co.
1756 Parke Ave., Baltimore, Md.
Gettrust, J. F.............................................Galena Oil Co.
401 Neave Building, Cincinnati, Ohio.
Gayner, J. E.............................................D. L. & W.
1100 Lake St., Elmira, N. Y.
Hutchison, I. M.............................................
Apartado 2098, Mexico City, Mex.
Hall, J. W............................................. St. L. S-W. of Texas.
1315 East Bluff St., Ft. Worth, Tex.
Hill, J. A.............................................“The American Machinist.”
218 Williams St., New York, N. Y.
Hedendahl, T. A.............................................Union Pacific.
538 Equitable Building, Denver, Col.
Hogan, C. H.............................................N. Y. C. & H. R.
268 Lexington Ave., Buffalo, N. Y.

Hildreth, F. F........................................T. H. & I.
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# ERRATA.

On page 136 at the bottom of the page is the following formula:

$$\frac{\text{Plan}}{33000} = \text{H. P.} \qquad \frac{P \times d^2 \times S}{D} = \text{T. P.}$$

Now "S" is referred to in 3d line from bottom as being "speed in miles per hour." It should read, "S = Stroke in inches."

On page 164, referring to M. E. P., if no planimeter is available leave out the following part of the sentence, "*Distance to be measured by the proper scale of the spring.*"